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ABSTRACT

From John Glenn's mission to orbit Earth to the International Space Station program, space food research has met the challenge of providing food that tastes good and travels well in space. Early food dehydration was achieved by cutting meat, fish, and certain fruits into thin strips and drying them in sunlight. Rubbing food with salt or soaking it in salt water, an early form of curing food, also helped preserve it. Later techniques were developed for cooking, processing, preserving, and storing food in sealed containers. With the developments of pasteurization and canning, a much larger variety of foods could be stored and carried on long journeys. More recently, refrigeration and quick-freezing have been used to help preserve food flavor and nutrients and prevent spoilage. While these forms of packaged food products are fine for travel on Earth, they are not always suitable for use on space flights. There are limitations to weight and volume when traveling, and the microgravity conditions experienced in space also affect the food packaging. This guide provides in-depth information about preserving and packaging food for space. Also included are three activities for grades K-4 and five activities for grades 5-8. (ASK)

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Educational Product	
Educators	Grades K–8

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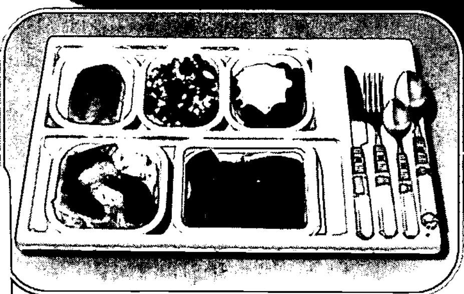
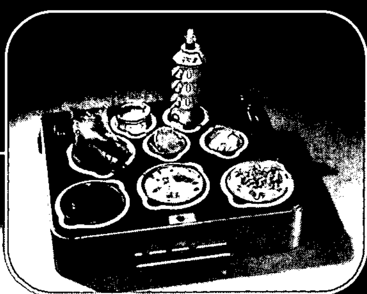
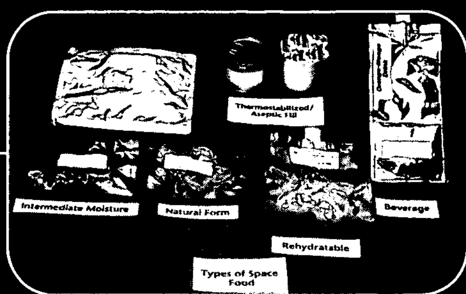
SPACE FOOD AND NUTRITION

An Educator's Guide With Activities in Science and Mathematics







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Space Food and Nutrition

An Educator's Guide With Activities in Science and Mathematics

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Activity Matrix

National Science Education Standards
National Research Council, 1996
Grades K–8

	Food Preparation for Space	Food Selection	Planning and Serving Food	Classifying Space Food	Ripening of Fruits and Vegetables	Mold Growth	How Much Is Waste?	Dehydrating Food for Space Flight
Science as Inquiry Abilities necessary to do scientific inquiry	√	√	√	√	√	√	√	√
Life Science Matter, energy, and organization in living systems	√	√	√		√	√		
Science in Personal and Social Perspectives Personal Health	√	√	√	√	√	√		√
Physical Science Properties of objects and materials		√					√	
Position and motion of objects			√					

Activity Matrix

National Mathematic Standards
National Council of Teachers of Mathematics, 1988
Grades K–8

	Food Preparation for Space	Food Selection	Planning and Serving Food	Classifying Space Food	Ripening of Fruits and Vegetables	Mold Growth	How Much Is Waste?	Dehydrating Food for Space Flight
Computation	√	√	√				√	√
Measurement	√				√	√	√	√
Reasoning	√	√	√	√	√	√	√	√
Observing	√	√	√	√	√	√	√	√
Communicating	√	√	√	√	√	√	√	√

Introduction

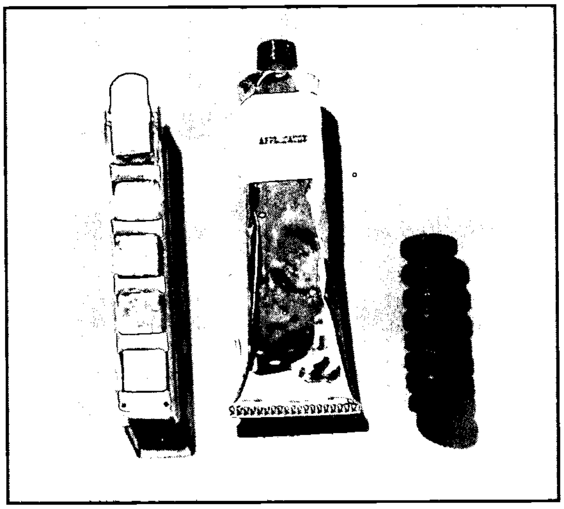
From John Glenn's mission to orbit Earth to the International Space Station program, space food research has met the challenge of providing food that tastes good and travels well in space. To better understand this process, we can look back through history. Explorers have always had to face the problem of how to carry enough food for their journeys. Whether those explorers are onboard a sailing ship or on the Space Shuttle, adequate storage space has been a problem. Food needs to remain edible throughout the voyage, and it also needs to provide all the nutrients required to avoid vitamin-deficiency diseases such as scurvy.

Early in history, humans discovered that food would remain edible longer if it were dried and stored in a cool dry place until it was time to be consumed. Early food dehydration was achieved by cutting meat, fish, and certain fruits into thin strips and drying them in sunlight. Rubbing food with salt or soaking it in salt water, an early form of curing food, also helped preserve it. Later techniques were developed for cooking, processing, preserving, and storing food in sealed containers. With the developments of pasteurization and canning, a much larger variety of foods could be stored and carried on long journeys. More recently, refrigeration and quick-freezing have been used to help preserve food flavor and nutrients and prevent spoilage.

While these forms of packaged food products are fine for travel on Earth, they are not always suitable for use on space flights. There are limitations to weight and volume when traveling and the microgravity conditions experienced in space also affect the food packaging. Currently, there is limited storage space and no refrigeration. To meet these challenges, special procedures for the preparation, packaging, and storing of food for space flight were developed.

Mercury

In the early days of the space program, known as Project Mercury, space flights lasted from a few minutes to a full day. Because of the short duration, complete meals were not needed. The major meal was consumed prior to the flight. However, the Mercury astronauts did contribute to the development of space food. They tested the physiology of chewing, drinking, and swallowing solid and liquid foods in a microgravity environment. These first astronauts found themselves eating bite-sized cubes, freeze-dried foods, and semi-liquids in aluminum toothpaste-type tubes. The food was unappetizing, and there were problems when they tried to rehydrate the freeze-dried foods.



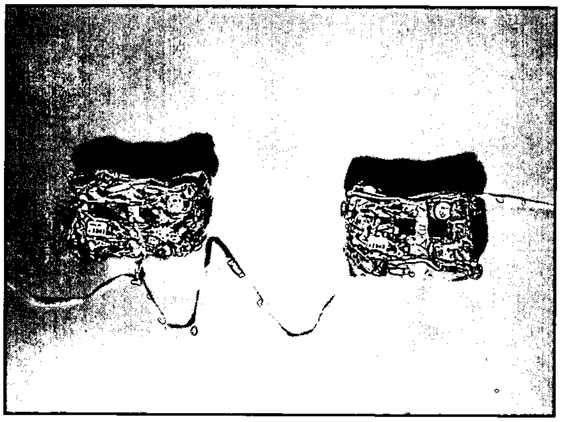
Early Project Mercury flight food: food tube and dry bite-sized snacks with a gelatin coating, which was necessary to control crumbling.

The tube foods offered many challenges to food development. First, a method of removing the food from the tube was needed. A small straw was placed into the opening. This allowed the astronauts to squeeze the contents from the tube directly into their mouths. This is similar to drinking your favorite soda from a straw, except that the food was a thicker substance. Special materials were developed to coat the inner surface of the aluminum tubes to prevent the formation of hydrogen gas as a result of contact between metal and the acids contained in some foods, such as applesauce. This aluminum tube packaging often weighed more than the food it contained. Because of this, a lightweight plastic container was developed for future flights.

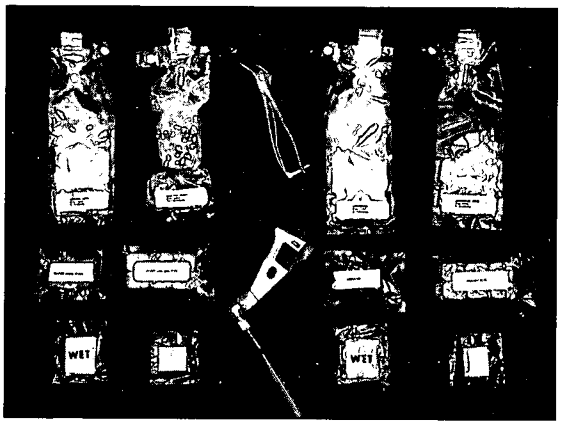
During the later Mercury test flights, bite-sized foods were developed and tested. These were solid foods processed in the form of compressed, dehydrated bite-sized cubes. The cubes could be rehydrated by saliva secreted in the mouth as food was chewed. Foods floating about in a microgravity environment could damage equipment or be inhaled; therefore, the cubes were coated with an edible gelatin to reduce crumbling. These foods were vacuum-packed into individual serving-sized containers of clear, four-ply, laminated plastic film for storage. This packaging also provided protection against moisture, loss of flavor, and spoilage.

Gemini

The major advancements in food items during the Gemini period were more variety and improved packaging. The dehydration process provided foods that were similar in appearance—including color, taste, shape, and texture—to freshly prepared food products. Some examples of the food flown on Gemini missions included grape and orange drinks, cinnamon toasted bread cubes, fruit cocktail, chocolate cubes, turkey bites, applesauce, cream of chicken soup, shrimp cocktail, beef stew, chicken and rice, and turkey and gravy.



Gemini meal wrap.



Sample types of food that have been dehydrated and packaged in cellophane for use by Gemini astronauts.

Dehydration occurs naturally in warm climates, and in cold climates, it is called freeze drying. Freeze-drying techniques in the space program consist of slicing, dicing, or liquefying prepared food to reduce preparation time. After the food has been cooked or processed, it is quick-frozen, then placed on drying trays and put into a vacuum chamber where the air pressure is reduced. Heat is then applied through heating plates. Under these conditions of reduced pressure and increased temperature, the ice crystals in the frozen food boil off, and the water vapor that is left is condensed back to ice on cold plates in the vacuum chamber. Because water is the only thing removed in this process, the freeze-dried food has all the essential oils and flavors. The texture is porous and can be easily rehydrated with water for eating.

To rehydrate food, water was injected into the package through the nozzle of a water gun. The other end of the package had an opening in which the food could be squeezed out of the package into the astronaut's mouth. Because of the size of the opening, food particle size was limited. After the meal had been completed, germicidal tablets were placed inside the empty package to inhibit microbial growth on any leftovers.

The advantages of freeze-dried foods were paramount in their development. The food is lightweight because the water has been removed. The food has a longer shelf life and can be stored at room temperature. The food also has flavors and textures more closely resembling that of the original fresh food items.

Adequate nutrient intake became a health concern with extended space flights in the Gemini program. Each crew member was supplied with 0.58 kilograms of food per day. These included dehydrated juices, freeze-dried and dehydrated foods, and compressed, noncrumbling, bite-sized foods. These made up the three meals a day that the astronauts ate. Meals were planned in advance, and the menu was repeated every 4 days.

Apollo

The preparation, handling, and consumption of space foods during the Mercury and Gemini missions provided valuable experience for the further development of space foods for future space flights. The Apollo program used food packages similar to those used on Gemini, but the variety of foods was considerably greater. Rehydratable food was encased in a plastic container referred to as the "spoon bowl." Water was injected into the package through the nozzle of a water gun. After the food was rehydrated, a pressure-type plastic zipper was opened, and the food was removed with a spoon. The moisture content allowed the food to cling to the spoon, making eating more like that on Earth.

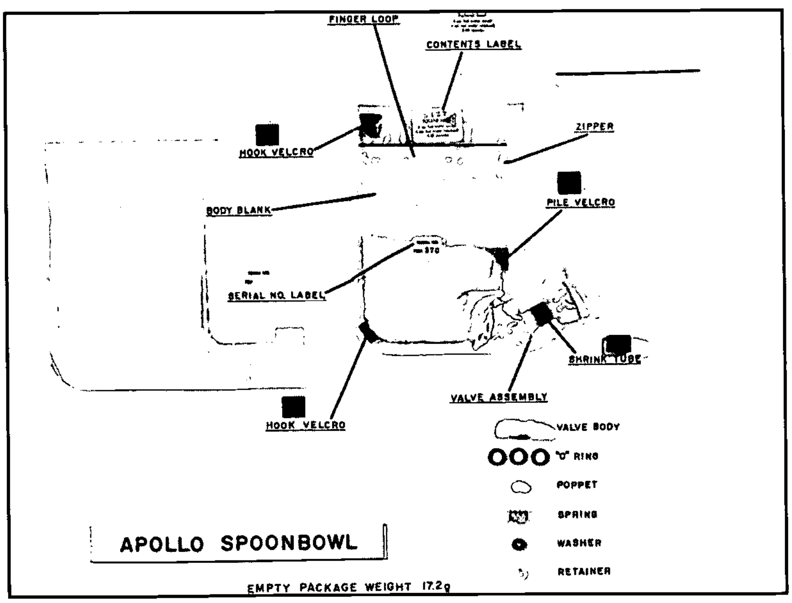
Another new package, the "wetpack" or thermostabilized flexible pouch, required no water for rehydration because water content was retained in the food. There were two types of thermostabilized containers: a flexible pouch of a plastic and aluminum foil laminate and a can with a full panel pullout lid. A disadvantage to the canned products was the added weight, which was approximately four times that of rehydratable foods. With these new packages, Apollo astronauts could see and smell what they were eating as well as eat with a spoon for the first time in space. This added enjoyment to the meals, which was missing in the earlier packages and products. The storage space for the new packaging allowed for one week's worth of rations for one astronaut to fit in a pressure-resistant container the size of three shoe boxes.

The Apollo missions to the Moon presented an enormous challenge to space food. The Mercury feeding tube was reintroduced as a backup food system. It contained a special formulation rather than the natural food purees used during Mercury. On Apollo flights, foods and drinks were reconstituted with either hot or ambient (room temperature) water. Some of the foods consumed on Apollo were coffee, bacon squares, cornflakes, scrambled eggs, cheese crackers, beef sandwiches, chocolate pudding, tuna salad, peanut butter, beef pot roast, spaghetti, and frankfurters.

Visit *http://spacelink.nasa.gov/space.food* to see and download the Apollo Food List.

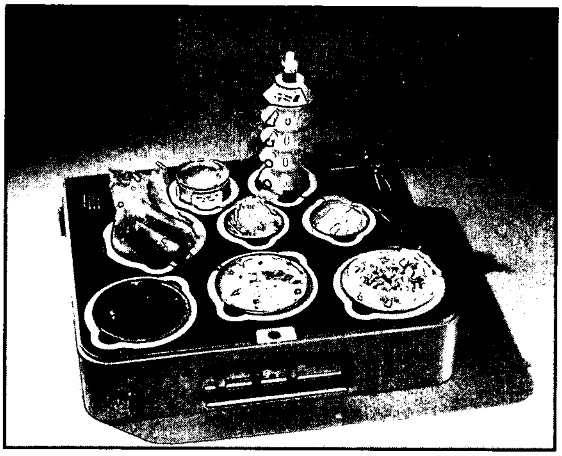
A close-up view of an Apollo spoon bowl package before rehydration and opening. This package was called a "spoon bowl" to differentiate it from Gemini and early Apollo food packages, which required that food be squeezed from a tube directly into the mouth. This type of package resulted in significant improvements in food consumption and crew comfort with food. Hot water was injected to rehydrate the food. The top of the container was opened with a pair of scissors, and the meal was eaten with a spoon.

Apollo meal wrap.



These Apollo spoon bowl parts show the complexity and engineering that went into the earlier years of space flight food packaging.

Skylab



This Skylab food tray had individual recessed compartments into which the canned food item was placed for heating. At meal time, the crew member selected the meal and placed the items to be warmed in the food tray.

Skylab Astronaut Owen K. Garriott eating in the Skylab dining area.

The dining experience on Skylab was unlike any other space flight. The Skylab laboratory had a freezer, refrigerator, warming trays, and a table. Eating a meal on Skylab was more like eating a meal at home. The major difference was the microgravity environment.

The supply of food onboard was sufficient to feed three astronauts for approximately 112 days. The menu was designed to meet each individual astronaut's daily nutritional requirements based on age, body weight, and anticipated activity. Each astronaut's caloric intake was 2,800 calories a day. These nutritional requirements were part of the life science experiments conducted on Skylab.

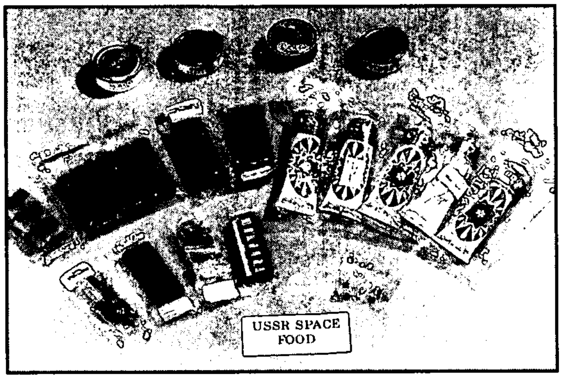
Skylab foods were packaged in specialized containers. The rehydratable beverages were packaged in a collapsible accordion-like beverage dispenser. All other foods were packaged in aluminum cans of various sizes or rehydratable packages.

To prepare meals, the Skylab crew placed desired food packages into the food warmer tray. This was the first device capable of heating foods (by means of conduction) during space flight. Foods consisted of products such as ham, chili, mashed potatoes, ice cream, steak, and asparagus.

Visit *http://spacelink.nasa.gov/space.food* to see and download the Skylab Food List.

Apollo-Soyuz Test Project

American astronauts on the Apollo-Soyuz Test Project were provided meals similar to those consumed on Apollo and Skylab flights. Russian meals were composed of foods packaged in metal cans and aluminum tubes. Their spacecraft had a small heating unit onboard, and individual menus were selected for each cosmonaut. In general, a meal consisted of meat or meat paste, bread, cheese, soup, dried fruit and nuts, coffee, and cake.



Russian space food.

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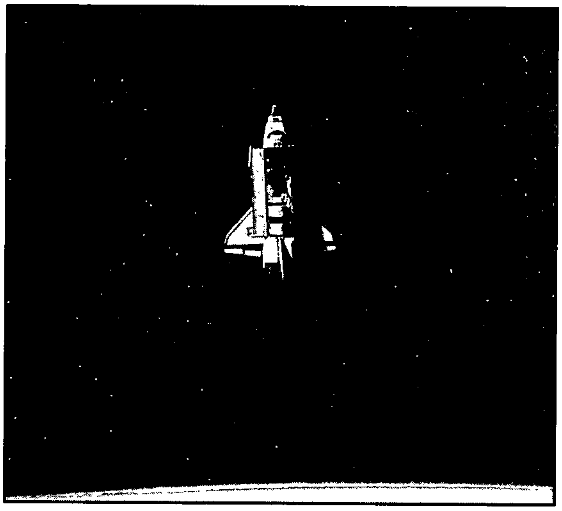
Space Shuttle

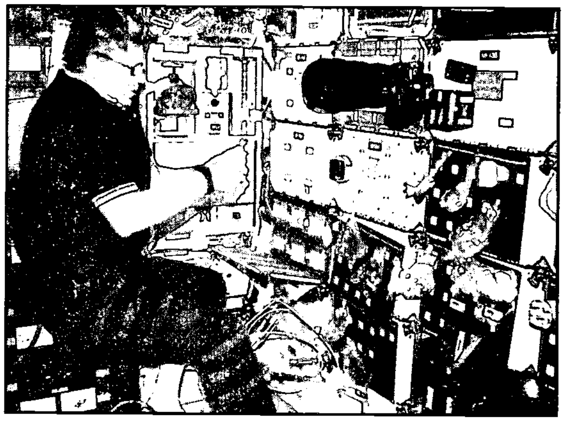
For the Space Shuttle program, a more Earth-like feeding approach was designed by updating previous food package designs and hardware items. Food variety expanded to 74 different kinds of food and 20 kinds of beverages. The changes were driven by the relatively large crews and regularly scheduled space flights. A standard Shuttle menu is designed around a typical 7-day Shuttle mission. Astronauts may substitute items from the approved food list to accommodate their own tastes or even design their own menus, but these astronaut-designed menus are checked by dietitians to ensure that they provide a balanced supply of nutrients.



STS-7 SPAS view of *Challenger*

On the Shuttle, food is prepared at a galley installed in the orbiter's middeck. This modular unit contains a water dispenser and an oven. The water dispenser—which can dispense hot, chilled, or ambient water—is used for rehydrating foods, and the galley oven is used to warm foods to the proper serving temperature. The oven is a forced-air convection oven and heats food in containers different in size, shape, and material. A full meal for a crew of four can be set up in about 5 minutes. Reconstituting and heating the food takes an additional 20–30 minutes. A meal tray is used as a dinner plate. The tray attaches to the astronaut's lap by a strap or can be attached to the wall. Eating utensils consist of a knife, a fork, a spoon, and a pair of scissors to open food packages. Many astronauts will tell you that one of the most important things they carry in their pockets is a pair of scissors. They could not eat without them!

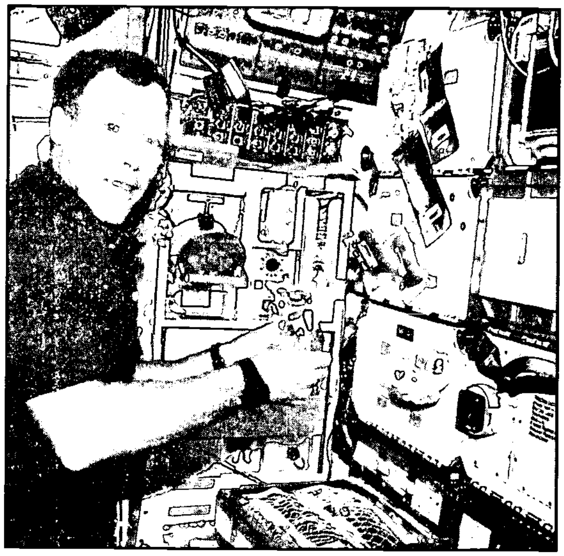
Weight and volume issues have always driven the design of any hardware to be taken into space. Food and beverage packaging is no exception. As Shuttle mission length increased, certain food and beverage packages required



Prepared foods on Shuttle food trays Velcroed to middeck stowage lockers.

modification. Rigid square rehydratable packages were being used but proved cumbersome and problematic on longer missions. Packages made of a lighter flexible material were developed and first tested on STS-44 (1991). These Extended Duration Orbiter (EDO) packages are made of flexible plastic and have a valve for inserting water. These eventually replaced the rigid square rehydratable packages on a permanent basis. In addition, a trash compactor was developed to reduce the volume of the trash, and the new packages were designed to be compatible with the compactor.

Visit *http://spacelink.nasa.gov/space.food* to see and download the Space Shuttle Food List and Shuttle Standard Menu.



STS-91 onboard view: Astronaut Dominic Gorie prepares a meal on the middeck of the Space Shuttle *Discovery*. Gorie prepares to use the nearby galley to add water to one of the rehydratable packages.

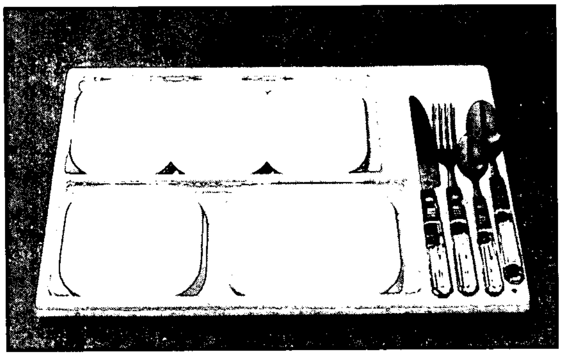
International Space Station

The International Space Station (ISS) will become operational on a full-time basis with a crew of three. Later, the crew size will grow to a maximum of seven people. The crew will reside in the Habitation Module (HAB). Food and other supplies will be resupplied every 90 days by the Multi-Purpose Logistics Module (MPLM). The MPLM is a pressurized module carried in the Space Shuttle payload bay that is used to transport materials and supplies. The food system described here is for the completed ISS and will be considerably different from the Space Shuttle food system. But until 2004 when the HAB module is launched, ISS residents will utilize a joint U.S.-Russian food (Shuttle-*Mir*) system.

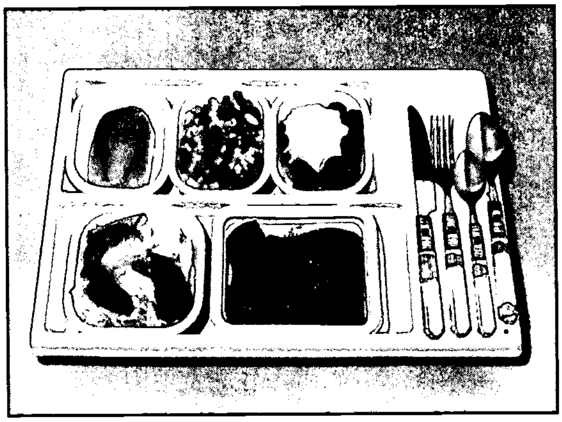
The fuel cells, which provide electrical power for the Space Shuttle, produce water as a byproduct, which is then used for food preparation and drinking. However, on the ISS, the electrical power will be produced by solar arrays. This power system does not produce water. Water will be recycled from a variety of sources, but that will not be enough for use in the food system. Therefore, most of the food planned for the ISS will be frozen, refrigerated, or thermostabilized (heat processed, canned, and stored at room temperature) and will not require the addition of water before consumption. Although many of the beverages will be in the dehydrated form, concentrated fruit juices will be added to the beverages offered and will be stored in the onboard refrigerator.

Similar to the Space Shuttle, the ISS beverage package is made from a foil and plastic laminate to provide for a longer product shelf life. An adapter located on the package will connect with the galley, or kitchen area, so that water may be dispensed into the package. This water will mix with the drink powder already in the package. The adapter used to add water also holds the drinking straw for the astronauts. The food package is made from a microwaveable material. The top of the package is cut off with a pair of scissors, and the contents are eaten with a fork or spoon.

Visit *http://spacelink.nasa.gov/space.food* to see and download the ISS Food List.



Empty International Space Station food tray.



International Space Station food tray (frozen food)

International Space Station frozen food storage: Food will be stowed in pullout drawers, which allow complete viewing of drawer contents. Lipped edges on the food package interface with the storage container, oven, and serving tray.

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Food Systems Engineering Facility

The kinds of food the astronauts eat are not mysterious concoctions but foods prepared here on Earth, with many commercially available on grocery store shelves. Diets are designed to supply each crew member with all the recommended dietary allowances of vitamins and minerals necessary to perform in the environment of space.

Foods flown in space are researched and developed in the Foods Systems Engineering Facility at NASA Johnson Space Center in Houston, Texas. Foods are tested for nutritional value, how well they freeze dry, the storage and packaging process, and of course taste. Astronauts are asked to taste test food items. They use a simple form to rate the products on such things as appearance, color, odor, flavor, and texture. These components are rated using a numbering system. The Food Systems Engineering Facility uses the astronauts' ratings to help design better space food.

Four individuals participate in a cantaloupe "sensory evaluation" at the Food Systems Engineering Facility. This facility consists of several areas: Kitchen (shown), Freeze Drying Room, Packaging Room, Analytical Laboratory, and Packaging, Fabrication, and Tasting Area.

Astronauts select their menu about 5 months before they fly. For the ISS, they will choose 30-day flight menus. Crew members will store the food in the galley onboard the Station.

The astronauts will use a special tray on the ISS to hold their food during preparation and eating. Because everything drifts in a microgravity environment, utensils and food containers need to be held in place. Food trays will be designed on the basis of the food packages that will be used on the ISS. These trays will be different from those used on the Space Shuttle because the ISS will have a table available; the Space Shuttle does not. The ISS tray will attach to the table.

From the beginning of human space travel, food has been an important feature that has involved astronauts, technicians, and engineers. Because food is an important part of life, it is imperative that the space food system is the best it can be. Astronauts on the ISS cannot get into a car and go down to the local grocery store if they do not like what is for dinner. The supply of food must be nourishing and tasty so astronauts maintain their health during their important stays in space.

Types of Space Food

There are eight categories of space food:

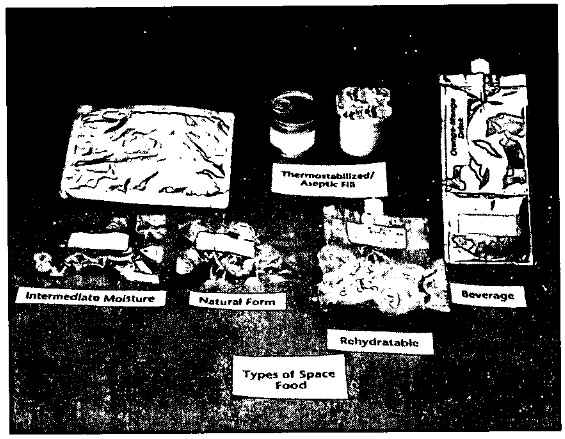
Rehydratable Food: The water is removed from rehydratable foods to make them easier to store. This process of dehydration (also known as freeze drying) is described in the earlier Gemini section. Water is replaced in the foods before they are eaten. Rehydratable items include beverages as well as food items. Hot cereal such as oatmeal is a rehydratable food.

Thermostabilized Food: Thermostabilized foods are heat processed so they can be stored at room temperature. Most of the fruits and fish (tuna fish) are thermostabilized in cans. The cans open with easy-open pull tabs similar to fruit cups that can be purchased in the local grocery store. Puddings are packaged in plastic cups.

Intermediate Moisture Food: Intermediate moisture foods are preserved by taking some water out of the product while leaving enough in to maintain the soft texture. This way, it can be eaten without any preparation. These foods include dried peaches, pears, apricots, and beef jerky.

Natural Form Food: These foods are ready to eat and are packaged in flexible pouches. Examples include nuts, granola bars, and cookies.

Irradiated Food: Beef steak and smoked turkey are the only irradiated products being used at this time. These products are cooked and packaged in flexible foil pouches and sterilized by ionizing radiation so they can be kept at room temperature. Other irradiated products are being developed for the ISS.



Food on the Space Shuttle comes in several categories. Represented here are: thermostabilized, intermediate moisture, rehydratable, natural form, and beverage.

Frozen Food: These foods are quick frozen to prevent a buildup of large ice crystals. This maintains the original texture of the food and helps it taste fresh. Examples include quiches, casseroles, and chicken pot pie.

Fresh Food: These foods are neither processed nor artificially preserved. Examples include apples and bananas.

Refrigerated Food: These foods require cold or cool temperatures to prevent spoilage. Examples include cream cheese and sour cream.

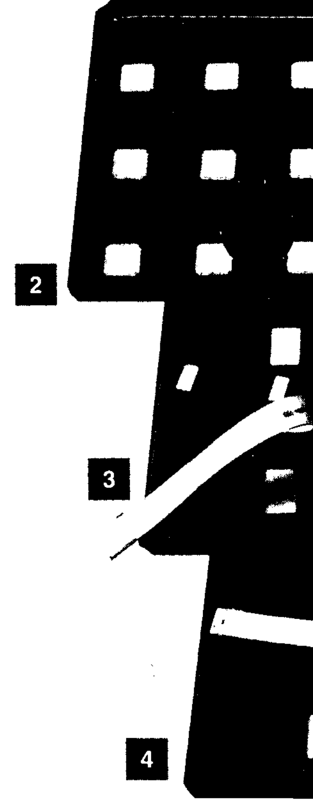
Microgravity

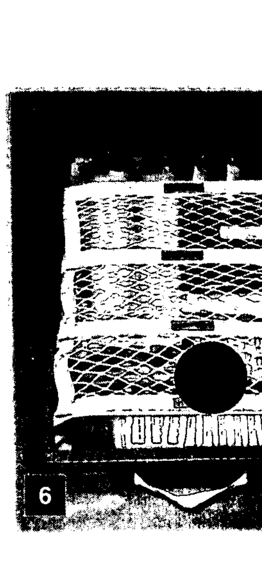
Food and how it is eaten and packaged have been greatly affected by the unique microgravity environment of space. A microgravity environment is one in which gravity's effects are greatly reduced. Microgravity occurs when a spacecraft orbits Earth. The spacecraft and all its contents are in a state of free-fall. This is why a handful of candy seems to float through the Space Shuttle when it is released. The candy does not drop to the floor of the Shuttle because the floor is falling, too.

Because of this phenomenon, foods are packaged and served to prevent food from moving about the Space Shuttle or ISS. Crumbs and liquids could damage equipment or be inhaled. Many of the foods are packaged with liquids. Liquids hold foods together and, freed from containers, cling to themselves in large drops because of cohesion. It is similar to a drop of water on a piece of wax paper. The only difference is that this drop of water is moving about the microgravity environment of the Space Shuttle. Special straws are used for drinking the liquids. They have clamps that can be closed to prevent the liquids from creeping out by the processes of capillary action and surface tension when not being consumed.

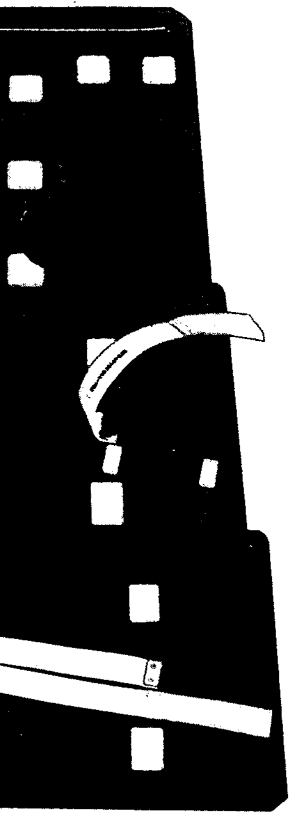
Microgravity also causes the utensils used for dining to float away. The knife, fork, spoon, and scissors are secured to magnets on the food tray when they are not being used. The effects of microgravity have had an enormous impact on the development of space food packaging, food selection, and related food system requirements.

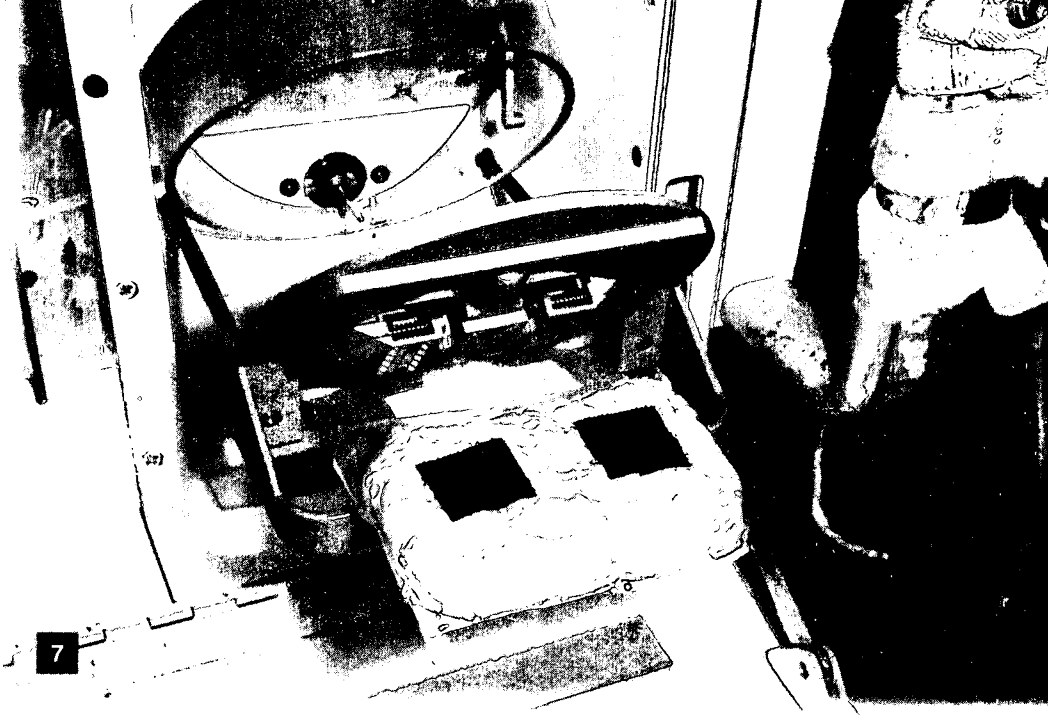
Astronaut Loren J. Shriver aboard STS-46 pursues several floating chocolate candies on the flight deck. Shriver is wearing a headset for communication with ground controllers.





1. **Shuttle galley.**
2. **Shuttle food tray top view.**
3. **Shuttle food tray bottom view, strap closed.**
4. **Shuttle food tray bottom view, strap open.**
5. **Shuttle rehydratable container components.**
6. **Shuttle stowage tray. Space Shuttle food is stowed in labeled pullout drawers in the middeck. Drawer contents are covered with a mesh, which allows top viewing of the drawer contents.**
7. **Shuttle galley. The Shuttle food galley consists of two parts: forced air convection oven and a rehydration station where hot, cold, or ambient temperature water can be dispensed.**
8. **Shuttle beverage packaging components.**
9. **Shuttle rehydratable food package. Top and bottom view of broccoli au gratin. Label shows name, preparation, and batch number. Bottom has Velcro for attachment to the Shuttle food tray.**
10. **Shuttle beverage containers.**
11. **Astronaut Dr. Franklin R. Chang-Diaz prepares a tortilla at the Shuttle food galley.**





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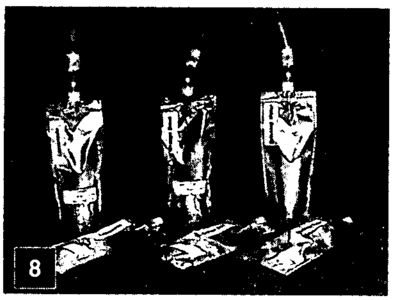

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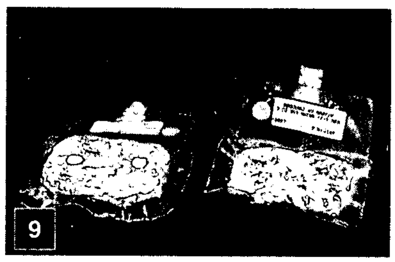

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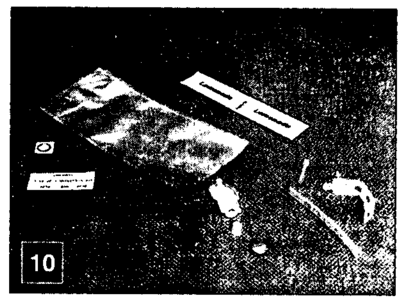

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11

Classroom Activities

These activities emphasize hands-on and cooperative involvement of students. Whenever possible, they make use of inexpensive and easily obtainable materials and tools.

Activities for Grades K–4

Activity 1: Food Preparation for Space
Activity 2: Food Selection
Activity 3: Planning and Serving Food

Activities for Grades 5–8

Activity 4: Classifying Space Food
Activity 5: Ripening of Fruits and Vegetables
Activity 6: Mold Growth
Activity 7: How Much Is Waste?
Activity 8: Dehydrating Food for Space Flight

Activity 1:
Food Preparation for Space

Objective

The students will measure the proper amounts and mix ingredients of rehydratable foods and drinks.

Science Standards

- **Science as Inquiry:** Abilities necessary to do scientific inquiry
- **Life Science:** Matter, energy, and organization in living systems
- **Science in Personal and Social Perspectives:** Personal health

Mathematics Standard

- **Computation**
- **Measurement**

Helpful Hints

Have students work in groups of four. For younger elementary students, the ingredients can be premeasured or the amounts can already be determined.

Nonfat dry milk does not have the thickness of whole milk, which is usually used for instant pudding. Suggest to students that they add water in increments, mix, and repeat this process until the desired consistency is achieved. (This may mean that as little as half of the suggested amount of water is needed.)

Materials Needed Per Group

1 package instant pudding mix
1 package instant drink crystals
Sugar
Artificial sweetener
Nonfat dry milk
Water
Straws
Plastic spoons
Plastic zip-locking sandwich bags

Background

Travelers have known for a long time that condensing food will make their journey easier. It is no different in the space program. Hikers use rehydratable foods so they do not have to carry very much weight with them. This makes it easier to travel. All weight going into space raises the fuel consumption at liftoff. It is important to eliminate as much weight as possible. Because the fuel cells on the Space Shuttle produce water as a byproduct, water is easily attainable. Therefore, taking foods along that can be rehydrated with this water make sense because this reduces the amount of weight on liftoff. The rehydrated foods also take up much less space, and space is a valuable commodity onboard the Space Shuttle.

Procedure for Rehydratable Food

Read the recipe label on the instant pudding. Calculate the amount of dry mix ingredients necessary for a single serving (weight ÷ number in group). The recipe for instant pudding calls for low-fat milk. Record the amount necessary for a single serving. Read the recipe label on the nonfat dry milk package, and calculate the amount necessary for a single serving of instant pudding (amount ÷ number in group). Measure the dry instant pudding ingredient and the proper amount of nonfat dry milk, and place both into a zip-locking bag. Shake and stir the dry ingredients until thoroughly mixed. Pour the correct amount of water necessary to dissolve the mixture. Close the zip-locking bag, and knead the package in your hands until thoroughly mixed.

Procedure for Rehydratable Beverage

Read the recipe label on the instant drink package. Calculate the amount of dry mix ingredients necessary for a single serving (amount ÷ number of single servings). Measure the dry ingredient, and place into a zip-locking sandwich bag. Calculate the amount of water necessary for a single serving (amount ÷ number of single servings). Measure the amount of water, and pour into the zip-locking bag. Close the zip-locking bag, and knead the package with your hands until thoroughly mixed. Calculate the amount of sugar or artificial sweetener for an individual serving and add.

Discussion

1. What changes did you observe?
2. Would the temperature of the water make a difference?
3. Why did you use a zip-locking bag as opposed to a bowl?
4. How would being in space affect the way you eat and prepare food?

Extensions

1. Have the students work together in groups to calculate the amount of dry and liquid ingredients to make equal servings for the group.
2. Are the steps listed on the package the only possible way for proper preparation? Have the students develop an alternative way of mixing dry and liquid amounts. Compare the results with the method given on the box label.
3. The recipe suggests chilling before serving. How can you eliminate refrigeration and still be able to serve it cold?
4. Use discussion questions for journal-writing topics.
5. Design a space food packaging label. Prepare a package label to include the following information: item name, manufactured date, instructions for preparing the item in space (if needed), a bar code for computerized inventory or conducting nutritional studies, and an expiration date. Labels include colored dots for crew member identification purposes:

<u>Color Dot Standards Table</u>

Red	Commander
Yellow	Pilot
Blue	Mission Specialist 1
Green	Mission Specialist 2
Orange	Mission Specialist 3
Purple	Mission Specialist 4 or Payload Specialist 1
Brown	Mission Specialist 5 or Payload Specialist 1

Labels also include the amount of water to rehydrate foods and the time and temperature needed to make it the best possible meal.

Lastly, place a Velcro dot on the package for attachment in microgravity. The Velcro "hooks" should be on the opposite side of the food package label.

Assessment

Have the students write procedures to make a rehydratable food and drink.

Food for Thought!

Pure orange juice or whole milk cannot be dehydrated. Orange drink crystals, when rehydrated, just make orange "rocks" in water. There is a freeze-dried orange juice, but it is difficult to rehydrate. Still, some astronauts request it. Whole milk does not dissolve properly. It floats around in lumps and has a disagreeable taste. Nonfat dry milk must be used in space packaging. During the 1960's, General Foods developed a synthetic orange-flavored juice called Tang, which can be used in place of orange juice. Today, this product is available in several different flavors.

Activity 2: Food Selection

Objective

The students will determine the acceptability of food products for space flight by participating in a sensory taste panel.

Science Standards

- **Science as Inquiry:** Abilities necessary to do scientific inquiry
- **Life Science:** Matter, energy, and organization in living systems
- **Science in Personal and Social Perspectives:** Personal health
- **Physical Science:** Properties of objects and materials

Mathematics Standard

- **Computation**

Helpful Hints

1. If a food is disliked, delete that item from the list.
2. Students should not discuss the foods with group members while tasting the foods. Students should do their own evaluations and then compare.
3. If necessary, use water and crackers between samples to remove prior tastes.
4. Many of these foods can be found at the local grocery store.

Materials Needed

Tray
Paper plates
Food samples (from menu list in appendix)
Drink samples (from menu list in appendix)
Water
Crackers
Taste Panel Evaluation Form
Taste Panel Procedure and Descriptive Comments Form

Background

Astronauts select their menu for space about 5 months before they fly. For the Space Shuttle, they select a menu that will serve them through the duration of their flight. For the ISS, they will choose a 30-day flight menu. These foods will be stored in the galley. A special taste panel is set up for the astronauts to taste a variety of foods when they are selecting their menus. This lets the astronauts know whether they like the food before going into space. Foods are tested for appearance, color, odor, flavor, and texture. It does not help astronauts to take foods into space if they will not eat them. This taste panel helps facilitate the selection of a desirable menu and reduces the amount of waste from unacceptable, uneaten, or partially eaten portions.

Procedure

Place the students into groups. These groups will be known as the expert groups, and each group should be assigned a type of space food. Each group will be responsible for tasting a variety of foods from their particular group. They will fill out the Taste Panel Evaluation Form, rating the appearance, color, odor, flavor, and texture. The students will rate these items using the numerical scores listed on the bottom of the form.

Each group will total the scores given each food and list them on the form. If an item receives a score of 6 or less, comments should be listed to explain the low score. All other items should be described by their good qualities. Brainstorm a list of descriptive words that can be used.

Discussion

1. Which space food would you prefer to take with you into space?
2. In each food type, which item received the highest score? Why?
3. In each food type, which item received the lowest score? Why?
4. Why do you think it is important that you test the foods before you take them into space?

Extensions

1. Have the students use the evaluation forms to choose a meal of their choice.
2. Use the descriptive words from the Taste Panel Evaluation Form to write a paragraph about the foods you have tested.

Assessment

When all of the tasting, evaluating, and computing have been done, each group should prepare a short presentation to share with the class about their findings.

Taste Panel Evaluation Form

ITEM				
Appearance				
Color				
Odor				
Flavor				
Texture				
Overall				
Comments				

High Scores:

9-Like Extremely
8-Like Very Much
7-Like Moderately

Mid Scores:

6-Like Slightly
5-Neither Like nor Dislike
4-Dislike Slightly

Low Scores:

3-Dislike Moderately
2-Dislike Very Much
1-Dislike Extremely

Taste Panel Procedure and Descriptive Comments Form

The following guidelines should be followed when rating a food product on the Taste Panel:

1. Emphasis is on the quality of the food product rather than on personal preferences such as likes and dislikes.
2. If you absolutely dislike the food product because of personal preferences, do not rate it.
3. If a product is rated below a 6 for any category, then note the reason in the space provided.
4. The overall rating is your overall general impression of the product, which is not necessarily an average of the other categories, but should be consistent with them.
5. Do not talk with other panelists during evaluations.
6. Refrain from smoking, eating, or drinking for 60 minutes prior to panels.
7. If necessary, use water or crackers between samples to clear the palate.
8. If you have a question regarding the Taste Panel, ask the person conducting the panel.

Descriptive Comments

Here is a list of descriptive terms that can be used to describe an attribute of a food and be an aid for food development. You may use the list below to describe attributes of a food sample. A score of 6.0 or below should have some descriptive comment that will explain a low score.

Taste/Order	Texture	Color/Appearance
Bitter	Crisp	Dull
Sweet	Soft	Lustrous
Sour	Hard	Sparkling
Salty	Stringy	Bright
Oxidized	Tough	Light
Rancid	Chewy	Dark
Stale	Firm	Greasy
Tasteless	Fine	Glossy
Metallic	Grainy	Cloudy
Flat	Gummy	Old
Musty	Lumpy	Pale
Yeasty	Mushy	
Floral	Pasty	
	Rubbery	
	Sticky	
	Stiff	
	Tender	
	Greasy	
	Juicy	

Activity 3: Planning and Serving Food

Objective

The students will plan a 5-day flight menu and design a food tray that can be used in space.

Science Standards

- **Science as Inquiry:** Abilities necessary to do scientific inquiry
- **Life Science:** Matter, energy, and organization in living systems
- **Science in Personal and Social Perspectives:** Personal health
- **Physical Science:** Position and motion of objects

Mathematics Standard

- **Computation**

Helpful Hints

1. For K–1 students, food pictures from magazines and ads can be used to plan the menu. The students may also cut and paste pictures to construction paper to simulate the Space Shuttle food tray.
2. Some possible materials that can be used to build the food trays are boxes, cardboard, hook and loop tape (Velcro), magnets, foil, wood, construction paper, and glue. Encourage students to be creative in their designs.

Materials

USDA Food Pyramid Guide (Appendix G)
Food group and suggested daily servings chart (Activity 4)

Background

Astronauts use special trays in space because of the special microgravity environment. These trays are designed to hold everything in place while food is being prepared and eaten. On the Space Shuttle, the trays used have straps on the back so that the astronauts can attach them to either the wall or their leg in order to hold them in place. They also have hook and loop tape on them to attach to the foods and drink packages; utensils are held in place with magnets. The ISS food tray has compartments to hold special bowl-like containers. They snap into place and hold the food in the tray. These containers are similar to single-serving frozen food dishes that can be found in the grocery store. The only difference is that they are made of a hard plastic instead of aluminum or cardboard.

Procedure

The students will plan a nutritionally balanced 5-day menu for astronauts. It is important that astronauts receive the recommended daily caloric intake so they can maintain their energy level and good health. Use the Food Pyramid Guide in the appendix to nutritionally balance the meals. Using the recommended food group and suggested daily servings chart listed in Activity 4, choose foods that will fulfill the recommended daily allowances for the astronauts.

The students will design and build a tray to hold their meals. To help the astronauts eat their meals on the Space Shuttle, a special tray has been devised to help hold the different food types and packages in place. This prevents food from drifting in a microgravity environment.

Discussion

1. What types of problems might you face while trying to eat in space?
2. Are there other ways to serve space food?
3. Why is it important for astronauts to receive the recommended daily caloric and nutritional intake?

Extensions

Have the students plan and prepare a space food luncheon. The food trays the students designed and built will be used. The menu for the day will be selected from the International Space Station Daily Menu Food List. The school administration should be invited as well as community leaders and parents. Remember to invite the local media.

Students can cut food pictures from actual food containers and place rehydratables in zip-locking bags for Space Shuttle food. For ISS frozen foods, food pictures from frozen food packages can be cut to fit the recycled plastic frozen food containers. Foam core or plaster of paris can be used to give the package actual weight.

Assessment

Evaluate each food tray for design and usability. Verify that the meals planned are nutritionally balanced.

Activity 4: Classifying Space Food

Objective

To classify the space food manifested on the Space Shuttle or International Space Station food lists into the major food groups found in the Food Pyramid Guide.

Science Standards

- **Science as Inquiry:** Abilities necessary to do scientific inquiry
- **Science in Personal and Social Perspectives:** Personal health

Materials Needed

Baseline Space Shuttle Food and Beverage List (Appendix A)
International Space Station Daily Menu Food List (Appendix B)
USDA Food Guide Pyramid (Appendix G)

Background

The Food Guide Pyramid has been established to help people maintain a diet that is adequate in nutritional value. Maintaining good health in space is important, and to help do this, a good diet is imperative. Balanced meals of good nutritional food will help ensure that the astronauts will be able to perform their jobs in space.

The U.S. Department of Agriculture (USDA) has made recommendations for a healthy diet. Foods are grouped according to the nutrients they provide. Many foods, such as corn, are hard to place into a specific group. Sweet corn can be counted as a starchy vegetable, but corn tortillas are in the grain group. Dry beans and peas (legumes) can be counted as either a starchy vegetable or a meat.

The following is a web site that can be used to obtain more indepth information about the Food Guide Pyramid and nutrition:
http://www.usda.gov/fcs/cnpp/using.htm

Food Groups and Suggested Daily Servings Chart

Food Groups	Suggested Daily Servings
Grain (Bread, Cereal, Rice, and Pasta)	6 to 11 servings
Fruit	2 to 4 servings
Vegetable	3 to 5 servings
Meat (Meats, Poultry, Fish, Eggs, and Nuts)	2 to 3 servings
Dairy (Milk, Yogurt, and Cheese)	2 to 3 servings
Oil (Fats and Sweets)	Use sparingly

Procedure

Using the Baseline Space Shuttle Food and Beverage List or the International Space Station Daily Menu Food List, classify the foods into the major groups as shown above.

Discussion

1. Which foods did you find that can fit into more than one food group?
2. In your opinion, which food group had the better selection of foods?
3. Why is it important to maintain good health in space?
4. How does a balanced diet maintain good health?

Extensions

1. Have the class design their own ISS food menu for a 30-day crew rotation or Space Shuttle food menu for a 7-day rotation. Have them analyze how many times a particular food or drink item was served and if some items were served in combination with another (such as fish always served with french fries). Avoid monotonous or repetitive selection by increasing the variety of food choices.
2. Using a computer, create a data base file. Design a data base template that includes fields such as day (1, 2, 3, etc.), meal (breakfast, lunch, dinner, and a possible snack), and the six major food groups (grain, vegetable, fruit, dairy, meat, and oil). Enter the information from the menus and determine which meals are balanced ones by searching for any empty fields in the food groups.

Assessment

The students will compare and contrast their findings.

Activity 5:
Ripening of Fruits and Vegetables

Objectives

Compare and contrast the rate of ripening of fruits and vegetables when exposed to air and the effect of using a chemical inhibitive on that rate of ripening.

Measure the exposed surface area of ripened fruits and vegetables.

Science Standard

- **Science as Inquiry:** Abilities necessary to do scientific inquiry
- **Life Science:** Matter, energy, and organization in living systems
- **Science in Personal and Social Perspectives:** Personal health

Mathematics Standard

- **Measurement**

Materials Needed

Distilled water
Fruits such as apples and bananas
Vegetables such as carrots and celery sticks
Vitamin C tablets
Small deep plastic bowls
Knife
Large spoons
Paper plates

BACKGROUND

Food for the Space Shuttle is packaged and stowed in food lockers at Johnson Space Center in Houston, Texas, approximately a month before each launch and is kept refrigerated until shipped to the launch site. About 3 weeks before launch, the food lockers are sent to Kennedy Space Center in Florida. There, they are refrigerated until they are installed in the Shuttle 2 to 3 days prior to launch. Besides the meal and supplemental pantry food lockers, a fresh food locker is packed at Kennedy and installed on the Shuttle 18 to 24 hours before launch. The fresh food locker contains tortillas, fresh bread, breakfast rolls, fresh fruits such as apples, bananas, and oranges, and fresh vegetables such as carrots and celery sticks. During space flight, fresh fruits and vegetables have a short shelf life because of the absence of a refrigerator and must be consumed within the first 7 days of flight. Carrots and celery sticks are the most perishable items in the fresh food locker and must be consumed within the first 2 days of flight.

Onboard the ISS, refrigerators will be present, and refrigerated foods for the Station will include fresh and fresh-treated fruits and vegetables. Certain types of fruits and vegetables can have an extended shelf life of up to 60 days.

When certain fruits or vegetables are sliced open and exposed to air, the exposed cut surface turns brown in color. There are a number of processing techniques that can be employed to fresh-treat fruit and vegetables: irradiation, a wax coating, an ethylene inhibitor (ethylene is a plant hormone that causes ripening), controlled atmosphere packaging, modified atmosphere packaging, and the use of a chemical inhibitive.

This activity focuses on one of these processes—the use of a chemical inhibitive—as a way of packaging sliced fruits and vegetables as a single-serving, nonwaste food item. Slicing eliminates the weight and waste of a core and peelings.

Some foods are easily browned, such as bananas, apples, pears, and peaches. You can protect fresh fruit from browning by keeping it from being exposed to air. Another way is by treating the food with vitamin C.

Procedure

1. Pour water into two small deep bowls. Dissolve a vitamin C tablet into one, and leave the second as plain water. Label the first one "Vitamin C" and the second "Plain Water."
2. Cut a piece of fruit into six equal wedges.
3. Place two wedges into each of the prepared liquids. Be careful that each wedge is completely immersed in the liquid for about 10 minutes.
4. Remove each wedge with a spoon, and place on separately labeled paper plates.
5. Place the last two wedges on a paper plate labeled "Untreated."
6. Arrange the piece so that all of the cut surfaces are exposed to air.
7. Repeat steps 2 through 6 with each fruit and vegetable being tested.

8. Let all three plates sit for an hour, and observe for any browning.
9. Using a variety of tools (ruler, square centimeter graph paper, foil, etc.) to measure the brown, exposed area of the fruits and vegetables.

Discussion

1. Which fruit and which vegetable turned browner than the others?
2. Which fruit and which vegetable did not turn as brown as the others?
3. Can you think of another chemical inhibitive that could be used to preserve fruits and vegetables?
4. What would be the best way to pack fruits and vegetables for space flight?

Extensions

1. Does the amount of vitamin C in the water affect the rate that fruit and vegetables will turn brown? Test this hypothesis by using one-half tablet, one tablet, and two tablets of vitamin C in the water.
2. Will temperature affect the rate of browning on fruits and vegetables? Try the experiment again, but this time place them in the refrigerator and in a warm dark place for the same amount of time.
3. Lemon juice is a common ingredient listed in recipes for fruit pies. Repeat the experiment again to determine whether lemon juice has an effect on browning.
4. Use a vacuum pump to keep fresh fruit from being exposed to air (vacuum sealing). Observe the rate of browning.
5. Slicing, coring, and peeling are techniques for providing single servings and eliminating waste. Determine the amount of weight and volume reduced by slicing, coring, and peeling apples and oranges.

Assessment

The students will present their findings to the class. Classroom graphs and charts may be used to illustrate information learned.

Activity 6: Mold Growth

Objective

After observing mold growth on different types of bread, measure and record the growth rate.

Science Standards

- **Science as Inquiry:** Abilities necessary to do scientific inquiry
- **Life Science:** Matter, energy, and organization in living systems
- **Scieuce in Personal and Social Perspectives:** Personal Health

Mathematics Standard

- **Measurement**

Materials Needed

Variety of breads (such as white, brown, whole wheat, rye, and sourdough) with and without preservatives
Variety of tortillas (such as flour and corn) with and without preservatives
Plastic zip-locking sandwich bags (16.5 cm x 14.9 cm)
Marking pen
Tape
Knife
Metric ruler
Transparent centimeter grid sheet
Large tray
Student Data Sheets

Background

Flour tortillas have been a favorite bread item for space flight since 1985.* Tortillas are an acceptable bread substitute because of ease of handling and reduced crumb generation in microgravity. Frankfurters and peanut butter and jelly are some of the foods and spreads used with the tortillas to make sandwiches. The tortillas are also used as a bread accompaniment to many of the food entrees such as beef tips in gravy and ham slices. The Space Shuttle galley does not have refrigeration for food storage; hence, all foods are stowed in locker trays at room temperature. Spoilage problems are encountered with commercial tortillas on space flight missions longer than 7 days.

Molds are naturally present nearly everywhere in our environment. In nature, molds are needed to break down substances such as leaves and result in organic matter that enriches soil. When present in foods, however, molds may grow and cause an unsightly appearance and unappealing and unusual flavors. Some molds are capable of producing toxins, which are hazardous to human health. Dampness, warmth, oxygen, favorable pH, and the absence of light result in the optimum growth conditions for yeast, mold, and pathogenic bacterial growth. As mission length has increased, the need to develop a tortilla that is shelf stable at room temperature has become essential. A tortilla with a shelf life of 6 months was developed.

Foods and beverages are processed with preservatives to inhibit the growth of molds naturally present. The development of a shelf-stable tortilla for space flight required reducing the amount of available water, lowering the pH to prevent bacterial growth, and packaging in an oxygen-free environment to prevent mold growth. See the Space Tortilla Formulation (Recipe) in Appendix F.

Procedure

1. Measure and cut each bread and tortilla sample into a 10 x 10 cm square.
2. Cut a 5 x 5 cm square of paper, and dampen with water. Place into a numbered zip-locking sandwich bag.
3. Place each sample on dampened paper in the bag, and seal with a little air left in the bag. Tape the zip-locking seal as a safety measure.
4. List the ingredients from the information label on the food package wrapper. Identify flours, yeast, and preservatives. Label the package.
5. Place the labeled samples on a large tray to minimize handling. Keep the samples in a warm, dark place.
6. Make daily observations of any mold growth at the same time each day. Make observations of the types of mold present by noting the color and appearance of the molds and the rate of mold growth.
7. Measure the amount of mold surface area growth by placing a transparent centimeter grid over the sample.
8. Record your data on the Student Data Sheets.
9. Examine the mold with a stereo microscope or magnifier.

Caution: **Molds should be handled carefully. Do not**

* Tortillas were requested as part of the food manifest by Astronaut Rodolfo Neri Vela (Mexico), Payload Specialist, STS-61B, 1985.

open the zip-locking plastic bag, and do not remove the mold samples from the zip-locking plastic bags. The spores, which is how mold is dispersed, may spread throughout the classroom and could cause allergic reactions.

Discussion

1. Which bread type(s) exhibited more mold growth over a long period of time?
2. On which bread type did mold first appear?
3. Were there any breads that had no mold growth? Why?
4. What was the difference between the tortilla and the bread as far as mold growth?
5. Molds vary in color and appearance. Many are white and resemble cotton while others are green, brown, black, pink, or gray. While some molds will grow on a wide variety of foods, others grow best on fresh fruits or vegetables. Describe the mold(s) that appeared on the bread products.

Extensions

Repeat the experiment, and change the variables.

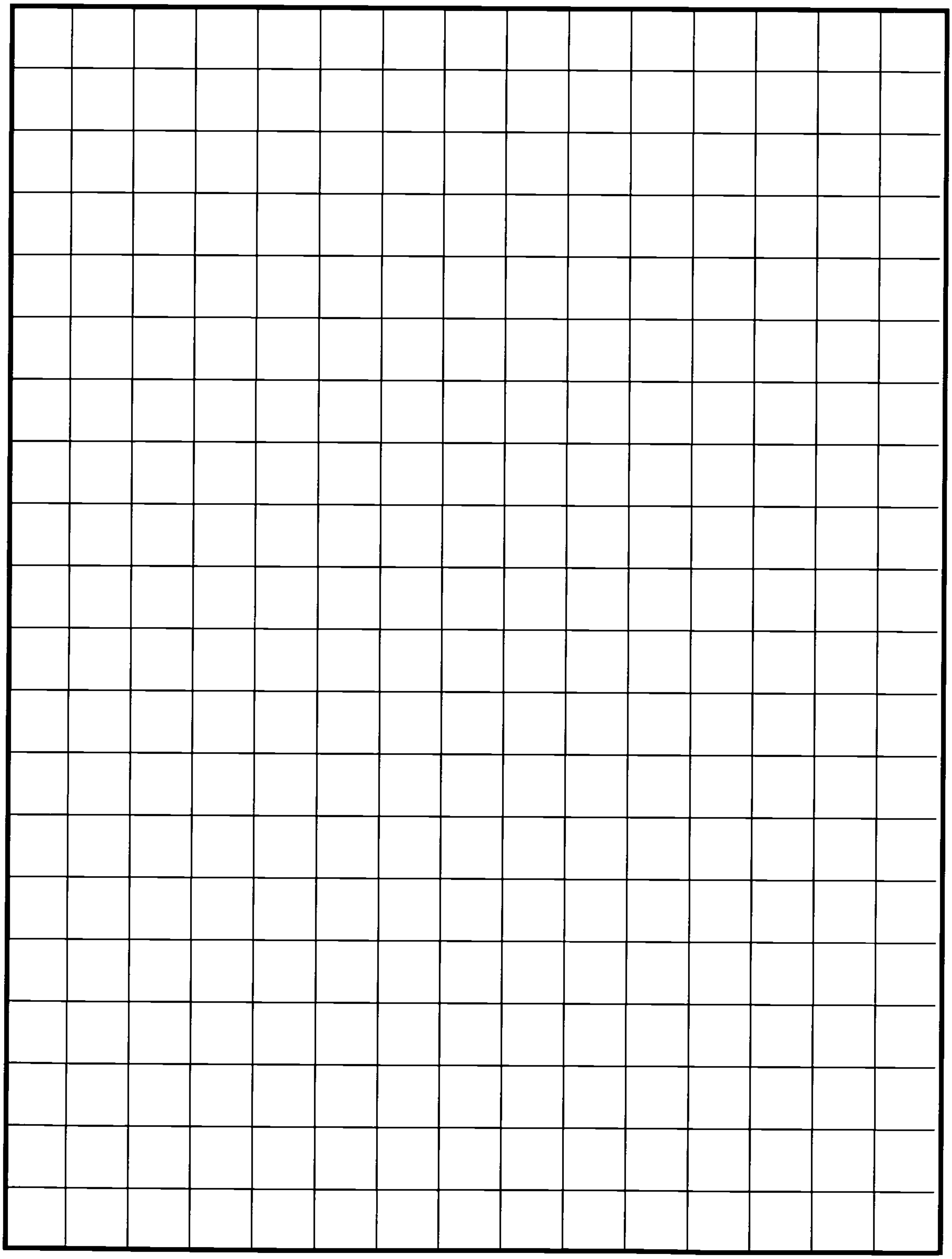
1. Place some bread samples in the dark, and expose other identical pieces in the light.
2. Place some bread samples in a cool place (refrigerator), and expose other identical samples in a warm place.
3. Repeat the experiment with other types of major food groups that have flown in space. The Space Shuttle fresh food locker contains crew-determined food items such as oranges, apples, carrots, and celery sticks. Try a fresh fruit such as an orange or apple, a fresh vegetable such as a carrot or celery stick, and a milk group item such as a natural cheese.
4. Observe which colors of molds grow on a variety of foods and which mold colors are more specific to a certain food group.
5. Compare the space flight shelf stable tortilla formulation (listed in Appendix F) with the ingredients listed on a grocery store tortilla package wrapper or in a tortilla recipe you find in a cookbook for an Earth-based tortilla.

Assessment

Conduct a classroom discussion about the findings, and collect the completed Student Data Sheets. Have the students graph their data.

Metric Area Grid Template

This 15 x 20 cm gridded sheet can be used to make transparencies, which can be placed on any object and used to measure how many square centimeters the object contains.



Student Data Sheet

Name

MOLD GROWTH DATA RECORD SHEET

Kind of Bread______________ Sample #_____ Preservative_____ (yes / no)

Time (Day)	Mold surface area (cm)	Daily Observations
1		
2		
3		
4		
5		
6		
7		
8		
9		
10		

Ingredients List:

1. ____
2. ____
3. ____
4. ____
5. ____
6. ____
7. ____
8. ____
9. ____
10. ____
11. ____
12. ____
13. ____
14. ____

Ingredients Identification Key:

Flour (F)

Preservative (P)

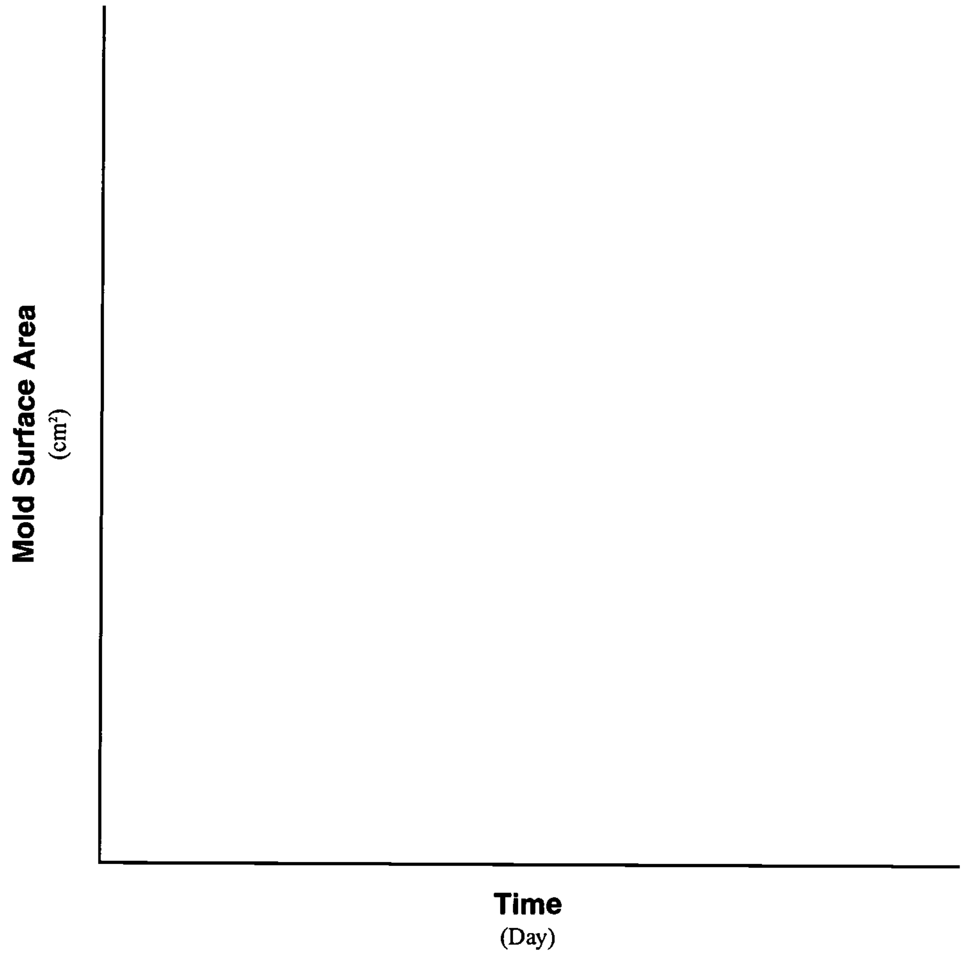
Yeast (Y)

36

Student Data Sheet

Name

Mold Growth Data Line Graph



Instructions

Plot surface mold area growth vs. time.
Plot data from each sample onto the line graph.
Use a different color for each sample recorded on the graph.
Indicate on the graph whether the sample is with or without preservatives.
If there are preservatives, state the number of different preservatives present.

Conclusions

Activity 7: How Much Is Waste?

Objective

Measure the mass and volume of a food package before and after repackaging for space flight, and determine the usable and waste portions of food selected for space flight.

Science Standards

- **Science as Inquiry:** Abilities necessary to do scientific inquiry.
- **Physical Science:** Properties and changes of properties of matter.

Mathematics Standard

- **Computation**
- **Measurement**

Materials Needed

Commercial food box such as a cereal box
Unshelled nuts: almond, cashew, macadamia, peanut
Fresh fruits: apple, grapefruit, lemon, orange
Metric balance
Weights
Plastic zip-locking snack and sandwich bags
Metric rulers
Calculators
Student Data Sheets

Background

The original design of the space food packaging for Projects Mercury, Gemini, and Apollo was light in weight and easily handled in microgravity, and it required minimum storage space. These specifications fit the prime life support design requirements for all spacecraft systems: minimum weight and volume, minimum power usage, reliability, ease of maintenance, environmental compatibility, integration with other systems, and crew compatibility.

As spacecraft design improved, allowing for longer flight durations and larger crew and cargo capabilities, the food manifest greatly improved. For instance, the Space Shuttle and ISS food lists contain nuts, shelled to reduce waste and mess. In addition, the lists also contain fruits and fruit juices. These fruits may be whole or presliced to reduce waste and mess.

Because of the increasing problem of orbital debris, the only substance dumped on orbit into space is excess water, a byproduct of electrical power generated from the Space Shuttle fuel cells. Onboard waste containment is a concern for space flight. A trash compactor is on the Space Shuttle and is also planned for the ISS to reduce the bulk of waste products.

Procedure

Part 1. Minimize the Mass of a Grocery Store Package

1. Weigh the package.
2. Calculate the mass and volume of the food package.
3. Open the package, remove the contents, and place them in a plastic zip-locking sandwich bag, removing as much air from the package as possible.
4. Weigh the new package.
5. Determine the volume of the new package.
6. Calculate the percentage of mass loss.
7. Calculate the percentage of volume loss.

Part 2. Determine the Usable and Waste Portions of 10 Nuts

Note: Use 10 nuts, and divide by 10 to come up with the amount for 1 nut.

1. Weigh 10 nuts.
2. Shell the nuts, and weigh the edible portion.
3. Collect the shells, and weigh the nut shells.
4. Calculate the percentage that is edible.
5. Calculate the percentage of waste.

Part 3. Determine the Edible and Waste Portions of a Fruit

1. Weigh the fruit.
2. Peel and core the fruit.
3. Weigh the edible portion of the fruit.
4. Weigh the peel and core of the fruit.
5. Calculate the percentage that is edible.
6. Calculate the percentage that is waste.

Discussion

1. Did the packaging make that much of a difference in weight? In volume?
2. After removing the parts of food that would not be eaten, did the weight decrease significantly?
3. Which food product lost the most weight? Was it because of packaging or waste portions of the food?

Extensions

1. Have the students find other types of food that contain waste portions.
2. Fruit juices are manifested for the ISS. Extract juice from selected fruit(s) and calculate the amount of juice available:

   % juice = liquid mass/total mass x 100

Assessment

Collect the completed Student Data Sheets, and determine whether the mathematical computations are correct. Through classroom discussion, determine usable and unusable portions of foods.

Student Data Sheet

Name

PART 1. MINIMIZE THE MASS OF A GROCERY STORE PACKAGE

Calculate the percentage of mass loss:

$$\% \text{ Package Mass Loss} = \frac{\text{store pack mass} - \text{space pack mass}}{\text{store pack mass}} \times 100$$

Calculate the percentage of volume loss:

$$\% \text{ Package Volume Loss} = \frac{\text{store pack volume} - \text{space pack volume}}{\text{store pack volume}} \times 100$$

PART 2. DETERMINE THE USABLE AND WASTE PORTIONS OF 10 NUTS

Calculate the percentage of the edible portion:

$$\% \text{ Edible} = \frac{\text{edible mass}}{\text{total mass}} \times 100$$

Calculate the percentage of the waste portion:

$$\% \text{ Waste} = \frac{\text{shell mass}}{\text{total mass}} \times 100$$

PART 3. DETERMINE THE EDIBLE AND WASTE PORTIONS OF A FRESH FRUIT

Calculate the percentage of the edible portion of the fresh fruit:

$$\% \text{ Edible} = \frac{\text{edible mass}}{\text{total mass}} \times 100$$

Calculate the percentage of the waste portion of the fresh fruit:

$$\% \text{ Waste} = \frac{\text{peel + core mass}}{\text{total mass}} \times 100$$

Activity 8: Dehydrating Food for Space Flight

Objective

Determine the percentage of water reduction by dehydrating fresh food items.

Science Standards

- **Science as Inquiry:** Abilities necessary to do scientific inquiry
- **Science in Personal and Social Perspectives:** Personal Health

Mathematics Standards

- **Measurement**
- **Computation**

Materials Needed

Vegetables: fresh green beans
Fruits: fresh apples, peaches, grapes, strawberries, or bananas
Food dehydrator
Balance
Weights
Plastic zip-locking sandwich bags

Background

Freeze-drying and other drying methods remove most of the water in foods. This food type (once rehydrated) provides a more solid-type diet and adds variety to the space flight menu.

Onboard the Space Shuttle, dehydrated foods and drinks make up a significant part of the menu selection. The major reason for using these dehydrated foods and drinks is because water is produced by the fuel cells as a byproduct, making water abundantly available for Space Shuttle food preparation. A significant weight reduction is achieved by rehydratable food and drinks.

For the ISS, electrical energy requirements are best met by using a renewable energy source. Solar arrays, which convert solar energy into electrical energy, do not produce water as a byproduct. The ISS food manifest has reduced the amount of food rehydratables significantly. Drinks, however, are still best handled in a rehydratable package for storage ease.

Procedure

1. Weigh the fruit or vegetable.
2. Cut up the food into small slices or pieces.
3. Place in the food dehydrator, and dehydrate.
4. Remove from the dehydrator, and allow to cool before weighing by placing in a plastic sandwich bag (so no moisture will be reabsorbed).
5. Weigh dehydrated food, being careful to subtract the weight of the empty zip-locking plastic bag.
6. Calculate the percentage of moisture lost in the food sample using the equation:

$$\% \text{ Moisture Loss} = \frac{\text{original mass} - \text{dehydrated mass}}{\text{original mass}} \times 100$$

Extension

Explore the rehydratability of different commercial food products obtained from camping of grocery stores. Weigh a known amount of dehydrated food, and place in a container of ambient water. Allow the food to completely rehydrate. Remove the food from the container, and blot dry. Weigh the rehydrated food product, and calculate the percentage of rehydration:

$$\% \text{ Rehydration} = \frac{\text{gain in mass} + \text{original mass}}{\text{original mass}} \times 100$$

Assessment

The students will write procedures for dehydrating fruit and vegetables.

Appendix A: Baseline Space Shuttle Food and Beverage List

Abbreviations

A/S	Artificial Sweetener
(B)	Beverage
(FF)	Fresh Food
(IM)	Intermediate Moisture
(I)	Irradiated
(NF)	Natural Form
(R)	Rehydratable
(T)	Thermostabilized

Beef w/BBQ Sauce (T)
Beef, Dried (IM)
Beef Patty (R)
Beef Steak (I)
Beef Stroganoff w/Noodles (R)
Beef, Sweet 'n Sour (T)
Beef Tips w/Mushrooms (T)

Bread (FF)

Breakfast Roll (FF)

Brownies (NF)

Candy,
- Coated Chocolates (NF)
- Coated Peanuts (NF)
- Gum (NF)
- Life Savers (NF)

Cereal,
- Bran Chex (R)
- Cornflakes (R)
- Granola (R)
- Granola w/Blueberries (R)
- Granola w/Raisins (R)
- Grits w/Butter (R)
- Oatmeal w/Brown Sugar (R)
- Oatmeal w/Raisins (R)
- Rice Krispies (R)

Cheddar Cheese Spread (T)

Chicken,
- Chicken, Grilled (T)
- Chicken Salad Spread (T)
- Chicken, Sweet 'n Sour (R)
- Chicken, Teriyaki (R)

Cookies,
- Butter (NF)
- Shortbread (NF)

Crackers, Butter (NF)

Eggs,
- Scrambled (R)
- Mexican Scrambled (R)
- Seasoned Scrambled (R)

Frankfurters (T)

Fruit,
- Apple, Granny Smith (FF)
- Apple, Red Delicious (FF)
- Applesauce (T)
- Apricots, Dried (IM)
- Banana (FF)
- Cocktail (T)
- Orange (FF)
- Peach Ambrosia (R)
- Peaches, Diced (T)
- Peaches, Dried (IM)
- Pears, Diced (T)
- Pears, Dried (IM)
- Pineapple (T)
- Strawberries (R)
- Trail Mix (IM)

Granola Bar (NF)

Ham (T)
Ham Salad Spread (T)

Jelly,
- Apple (T)
- Grape (T)

Macaroni and Cheese (R)

Noodles and Chicken (R)

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Nuts,
- Almonds (NF)
- Cashews (NF)
- Macadamia (NF)
- Peanuts (NF)
- Trail Mix (IM)

Peanut Butter (T)

Potatoes au Gratin (R)

Puddings,
- Banana (T)
- Butterscotch (T)
- Chocolate (T)
- Tapioca (T)
- Vanilla (T)

Rice and Chicken (R)
Rice Pilaf (R)

Salmon (T)

Sausage Patty (R)

Shrimp Cocktail (R)

Soups,
- Chicken Consomme (B)
- Mushroom (R)
- Rice and Chicken (R)

Spaghetti w/Meat Sauce (R)

Tortillas (FF)

Tuna,
- Tuna (T)
- Tuna Salad Spread (T)

Turkey,
- Turkey Salad Spread (T)
- Turkey, Smoked (I)
- Turkey Tetrazzini®

Vegetables,
- Asparagus (R)
- Broccoli au Gratin (R)
- Carrot Sticks (FF)
- Cauliflower w/Cheese (R)
- Celery Sticks (FF)
- Green Beans and Broccoli (R)
- Green Beans/Mushrooms (R)
- Italian (R)
- Spinach, Creamed (R)
- Tomatoes and Eggplant (T)

Beverages (B)

Apple Cider

Cherry Drink w/A/S

Cocoa

Coffee,
- Black
- w/A/S
- w/Cream
- w/Cream and A/S
- w/Cream and Sugar
- w/Sugar

Coffee (Decaffeinated),
- Black
- w/A/S
- w/Cream
- w/Cream and A/S
- w/Cream and Sugar
- w/Sugar

Coffee (Kona),
- Black
- w/A/S
- w/Cream
- w/Cream and A/S
- w/Cream and Sugar
- w/Sugar

Grape Drink
Grape Drink w/A/S

Grapefruit Drink

Instant Breakfast,
- Chocolate
- Strawberry
- Vanilla

Lemonade
Lemonade w/A/S

Lemon-Lime Drink

Orange Drink
Orange Drink w/A/S
Orange-Grapefruit Drink
Orange Juice
Orange-Mango Drink
Orange-Pineapple Drink

Peach-Apricot Drink

Pineapple Drink

Strawberry Drink

Tea,
- Plain
- w/A/S
- w/Cream
- w/Lemon
- w/Lemon & A/S
- w/Lemon & Sugar
- w/Sugar

Tropical Punch
Tropical Punch w/A/S

Condiments

Catsup (T)
Mayonnaise (T)
Mustard (T)
Pepper (Liquid)
Salt (Liquid)
Tabasco Sauce (T)
Taco Sauce (T)

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Appendix B:
International Space Station
Daily Menu Food List

Refrigerated

Dairy

Cheese
Cheese slices
Cream cheese
Sour cream
Yogurt, fruit

Fruits

Apple
Grapefruit
Kiwi
Orange
Plum

Frozen

Meat and Eggs

Beef:

Beef, brisket, BBQ
Beef, enchilada with spanish rice
Beef, fajita
Beef, patty
Beef, sirloin tips with mushrooms
Beef, steak, bourbon
Beef, steak, teriyaki
Beef, stir fried with onion
Beef, stroganoff with noodles
Luncheon meat
Meatloaf with mashed potatoes and gravy

Lamb:

Lamb, broiled

Poultry:

Chicken, baked
Chicken, enchilada with spanish rice
Chicken, fajita
Chicken, grilled
Chicken, oven fried
Chicken, pot pie
Chicken, stir fried with diced red pepper
Chicken, teriyaki with spring vegetables
Duck, roasted
Meatball, porcupine (turkey)

Pork:

Bacon
Bacon, Canadian
Ham, baked with candied yams
Pork, chop, baked with potatoes au gratin
Pork, sausage, patties
Pork, sweet and sour with rice

Seafood:

Fish, baked
Fish, grilled
Fish, sautéed
Lobster, broiled tails
Scallops, baked
Seafood, gumbo with rice
Shrimp, cocktail
Tuna, noodle casserole

Eggs:

Egg, omelet, cheese
Egg, omelet, vegetable
Egg, omelet, ham
Egg, omelet, sausage
Egg, omelet vegetable and ham
Egg, omelet, vegetable and sausage
Eggs, scrambled with bacon, hash browns sausage
Quiche, vegetable
Quiche, lorraine

Pasta mixtures:

Lasagna, vegetable with tomato sauce
Noodles, stir fry
Spaghetti with meat sauce
Spaghetti with tomato sauce
Tortellini with tomato sauce, cheese

Other:

Egg rolls
Enchilada, cheese with Spanish rice
Pizza, cheese
Pizza, meat
Pizza, vegetable
Pizza, supreme

Fruit

Apples, escalloped
Peaches, sliced with bananas, blueberries
Peaches with bananas, grapes, strawberries
Strawberries, sliced

Soups

Beef, stew
Broccoli, cream of
Chicken, cream of
Chicken noodle
Mushroom, cream of
Won ton

Grains

Biscuits
Bread
Cornbread
Dinner roll
Garlic bread
Sandwich bun, wheat/white
Toast, wheat/white
Tortilla

Breakfast items:

Cinnamon roll
French toast
Pancakes, buttermilk
Pancakes, apple cinnamon
Waffles

Pasta:

Fettuccine alfredo
Macaroni and cheese
Spaghetti

Rice:

Fried
Mexican/Spanish
White

Starchy Vegetables

Corn, whole kernel
Potato, baked
Potatoes, escalloped
Potatoes, oven fried
Potatoes, mashed
Yams, candied
Succotash
Squash corn casserole

Vegetables

Asparagus tips
Beans, green
Beans, green with mushrooms
Broccoli au gratin
Broccoli
Carrot coins
Cauliflower au gratin
Chinese vegetables, stir fry
Mushrooms, fried
Okra, fried
Peas
Peas with carrots
Squash, acorn with apple sauce and cinnamon
Zucchini, spears, fried

Desserts

Cakes:

Angel food cake
Brownie, chocolate
Chocolate fudge
Shortcake
Yellow cake with chocolate frosting

Dairy:

Ice cream, chocolate
Ice cream, strawberry
Ice cream, vanilla
Yogurt, frozen

Pies and Pastry:

Cheesecake, chocolate
Cheesecake, plain
Cobbler, peach
Pie, apple
Pie, coconut cream
Pie, pecan
Pie, pumpkin

Beverages

Apple juice
Grape juice
Grapefruit juice
Lemonade
Orange juice

Condiments

Margarine
Grated cheese

Cereals

Hot cereal:

Oatmeal
Cream of wheat
Grits

Thermostabilized

Fruit

Applesauce
Fruit cocktail
Peaches
Pears
Pineapple

Salads

Chicken salad
Tuna salad
Turkey salad

Vegetable:

Bean salad, three
Pasta salad
Potato salad, German
Sauerkraut

Soups

Chili
Clam chowder
Egg drop
Miso, Japanese
Vegetable

Desserts

Pudding, butterscotch
Pudding, chocolate
Pudding lemon
Pudding, tapioca
Pudding, vanilla

Condiments

Barbecue sauce
Catsup
Chili con queso
Cocktail sauce
Cranberry sauce
Dill pickle chips
Dips, bean
Dips, onion
Dips, ranch
Honey
Horseradish sauce
Jelly, assorted
Lemon juice
Mayonnaise
Mustard
Mustard, hot Chinese
Orange marmalade
Peanut butter (chunky, creamy, whipped)
Picante sauce
Sweet and sour sauce
Syrup, maple
Taco sauce
Tartar sauce

Beverages

Fruit juices:

Cranberry
Cranberry apple
Cranberry raspberry
Gatorade, assorted
Pineapple
Pineapple grapefruit
Tomato
V-8

Milk:

Skim
Low fat
Chocolate (low fat or skim)
Whole

Natural Form

Fruit

Apples, dried
Apricots, dried
Peach, dried
Pear, dried
Prunes
Raisin
Trail mix

Grains

Animal crackers
Cereal, cold
Chex mix
Crackers, assorted
Baked chips, tortillas
Baked chips, potato
Pretzels
Goldfish
Tortilla chips
Potato chips
Rye krisp, seasoned

Desserts

Cookies:

Butter
Chocolate chip
Fortune
Rice krispies treat
Shortbread

Snacks

Beef jerky

Nuts:

Almonds
Cashews
Macadamia
Peanuts

Candy:

Candy-coated chocolates
Candy-coated peanuts
Lifesavers
Gum (sugar free)

Eva Food

In-suit fruit bar

Rehydratable

Beverages

Apple cider
Cherry drink
Cocoa
Coffee (assorted)
Grape drink
Grapefruit drink
Instant breakfast, chocolate
Instant breakfast, vanilla
Instant breakfast, strawberry
Orange drink
Orange mango drink
Orange pineapple drink
Tea (assorted)
Tropical punch

Irradiated Meat

Beef steak
Smoked turkey

Appendix C: Gemini Standard Menu (4-day cycle)

Day 1, 5, 9

Meal A
Peaches
Bacon Squares (8)
Cinnamon Toast Bread Cubes (4)
Grapefruit Drink
Orange Drink

Meal B
Salmon Salad
Chicken and Rice
Sugar Cookie Cubes (4)
Cocoa
Grape Punch

Meal C
Beef and Potatoes
Cheese Cracker Cubes (4)
Chocolate Pudding
Orange-Grapefruit Drink

Day 2, 6, 10

Meal A
Fruit Cocktail
Sugar-Coated Cornflakes
Bacon Squares (8)
Grapefruit Drink
Grape Drink

Meal B
Potato Soup
Chicken and Vegetables
Tuna Salad
Pineapple Fruitcake (4)
Orange Drink

Meal C
Spaghetti and Meat Sauce
Ham and Potatoes
Banana Pudding
Pineapple-Grapefruit Drink

Day 3, 7, 11

Meal A
Peaches
Bacon Squares (8)
Strawberry Cubes (4)
Cocoa
Orange Drink

Meal B
Cream of Chicken Soup
Turkey and Gravy
Butterscotch Pudding
Brownies
Grapefruit Drink

Meal C
Pea Soup
Beef Stew
Chicken Salad
Chocolate Cubes (4)
Grape Punch

Day 4, 8

Meal A
Fruit Cocktail
Sausage Patties
Bacon Squares (8)
Cocoa
Grape Drink

Meal B
Potato Soup
Pork and Scalloped Potatoes
Apple Sauce
Orange Drink

Meal C
Shrimp Cocktail
Chicken Stew
Turkey Bites (4)
Dry Fruitcake (4)
Orange-Grapefruit Drink

Appendix D: Space Shuttle Standard Menu (4 days of a 7-day menu)

Day 1

Meal A
Dried Peaches
Cornflakes
Orange-Pineapple Drink
Cocoa

Meal B
Ham
Cheese Spread
Tortilla x2
Pineapple
Cashews
Strawberry Drink

Meal C
Chicken a la King
Turkey Tetrazzini
Cauliflower w/Cheese
Brownie
Grape Drink

Day 2

Meal A
Dried Pears
Beef Patties
Scrambled Eggs
Vanilla Instant Breakfast
Orange Juice

Meal B
Peanut Butter
Apple or Grape Jelly
Tortilla x2
Fruit Cocktail
Trail Mix
Peach-Apricot Drink

Meal C
Frankfurters
Macaroni and Cheese
Green Beans w/ Mushrooms
Peach Ambrosia
Tropical Punch

Day 3

Meal A
Dried Apricots
Breakfast Roll
Chocolate Instant Drink
Grapefruit Drink

Meal B
Turkey Salad Spread
Tortilla x2
Peaches
Granola Bar
Lemonade

Meal C
Spaghetti w/Meat Sauce
Italian Vegetables
Butterscotch Pudding
Orange Drink

Day 4

Meal A
Dried Peaches
Bran Chex
Orange-Mango Drink
Cocoa

Meal B
Dried beef
Cheese Spread
Applesauce
Peanuts
Tropical Punch

Meal C
Teriyaki Chicken
Rice and Chicken
Green Beans and Broccoli

Appendix E:
International Space Station Standard Menu (4 days of a 30-day menu)

Day 1

Meal A
Eggs Scrambled w/Bacon, Hash Browns, Sausage
Toast
Margarine
Jelly, Assorted
Apple Juice
Coffee/Tea/Cocoa

Meal B
Chicken, oven-fried
Macaroni and Cheese
Corn, whole kernel
Peaches
Almonds
Pineapple-Grapefruit Juice

Meal C
Beef Fajita
Spanish Rice
Tortilla Chips
Picante Sauce
Chili con Queso
Tortilla
Lemon Bar
Apple Cider

Day 2

Meal A
Cereal, cold
Yogurt, fruit
Biscuit
Margarine
Jelly, assorted
Milk
Cranberry Juice
Coffee/Tea/Cocoa

Meal B
Soup, cream of broccoli
Beef Patty
Cheese Slice
Sandwich Bun
Pretzels
Cried Apples
Vanilla Pudding
Chocolate Instant Breakfast

Meal C
Fish, sautéed
Tartar Sauce
Lemon Juice
Pasta Salad
Green Beans
Bread
Margarine
Angel Food Cake
Strawberries
Orange-Pineapple Drink

Day 3

Meal A
French Toast
Canadian Bacon
Margarine
Syrup
Orange Juice
Coffee/Tea/Cocoa

Meal B
Cheese Manicotti w/ Tomato Sauce
Garlic Bread
Berry Medley
Cookie, shortbread
Lemonade

Meal C
Turkey Breast, sliced
Mashed Sweet Potato
Asparagus Tips
Cornbread
Margarine
Pumpkin Pie
Cherry Drink

Day 4

Meal A
Cereal, hot
Cinnamon Roll
Milk
Grape Juice
Coffee/Tea/Cocoa

Meal B
Quiche Lorraine
Seasoned Rye Krisp
Fresh Orange
Cookies, Butter

Meal C
Soup, won ton
Chicken Teriyaki
Chinese Vegetables, stir-fry
Egg Rolls
Hot Chinese Mustard
Sweet 'n Sour Sauce
Vanilla Ice Cream
Cookies, fortune
Tea

Appendix F:
Space Tortilla Formulation (Recipe)

Ingredients	% by Mass
Wheat	61.79
Water	26.58
Glycerin	4.02
Shortening	3.71
Mono/Diglycerides	1.24
Salt	0.99
Baking Powder	0.87
Dough Conditioner	0.31
Fumaric Acid	0.19
Potassium Sorbate	0.15
Carboxymethyl Cellulose	0.12
Calcium Propionate	0.03
	100.00%

Preparation:

1. Dry ingredients are combined in a mixer using the wire beater attachments on a stir setting for 1 minute.
2. Shortening and mono/diglycerides are then added and blended to cornmeal consistency. Mix about 3–5 minutes using the wire beater attachment on speed 2.
3. Fumaric acid and potassium sorbate are weighed separately, added to 100 ml water, and set aside.
4. Glycerin and the remainder of water are combined and added to the mix using the dough hook attachment.
5. The fumaric acid and potassium sorbate solution is added to the dough and mixed on speed 2. Mix for about 10 minutes.
6. After mixing, allow the dough to rest 5 minutes, and then divide into 32 equal portions using a dough divider.
7. Round each individual piece by hand, place into muffin pans, and cover with plastic wrap.
8. Place into a 35.5-degree Celsius proofing chamber for 1 to 2 hours.
9. Dust each dough ball lightly with flour, and then form in a tortilla press.

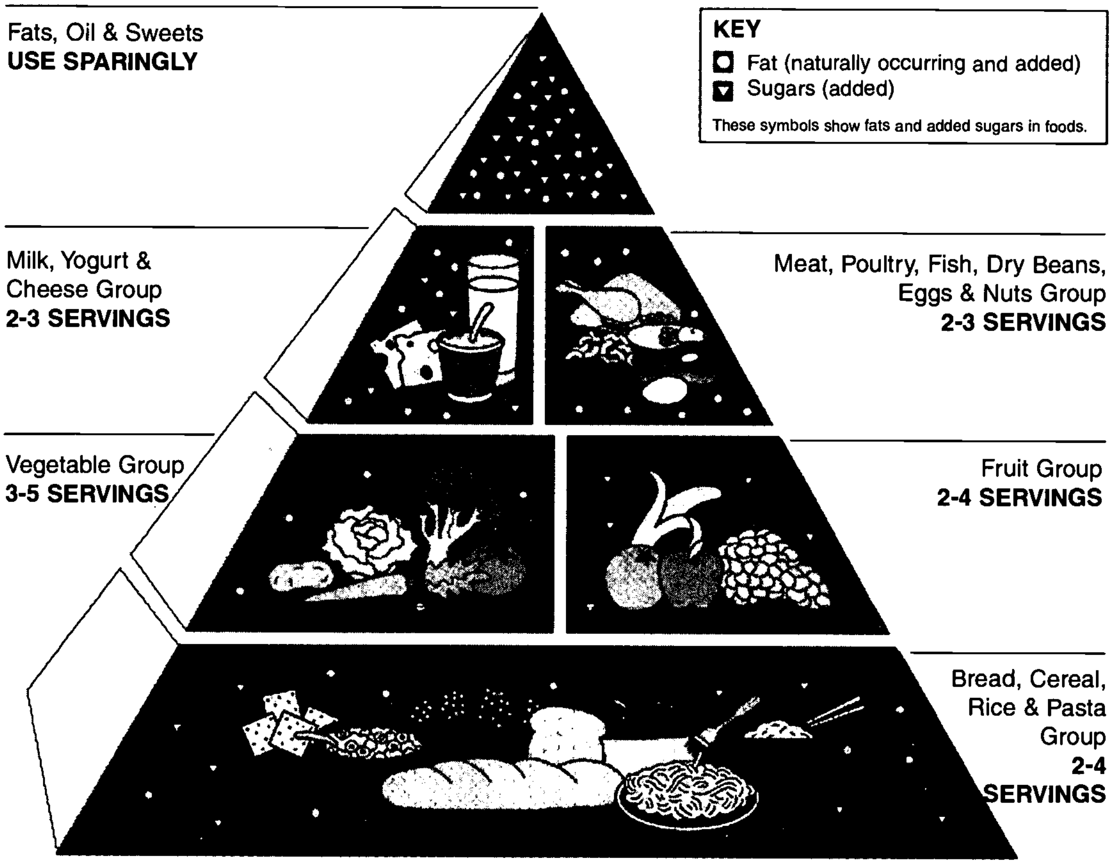
Cooking:

10. Place pressed tortilla in a preheat frying pan (190–204 degrees Celsius).
11. When uncooked surface begins to bubble, flip tortilla to cook the other side.
12. After both sides are baked, remove tortillas to a cool surface lined with waxed paper and allow to cool. Turn the tortillas to prevent condensation from forming between the waxed paper and the tortilla.

Packaging:

13. After cooling to room temperature, two tortillas are folded in half and placed in a three-ply foil laminate pouch (outside diameter: 6 1/2 X 8 1/8").
14. Insert an oxygen absorber into each pouch before the sealing operation.
15. Place the filled pouch in a vacuum seal chamber and back-flush with nitrogen three times and seal at 10 in. Hg vacuum.

Appendix G:
USDA Food Guide Pyramid



Source: U.S. Department of Agriculture/Department of Health and Human Services

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Visit *http://www.jsc.nasa.gov/pao/factsheets/#NP* to download the following NASA Publication and Fact Sheet:

NASA, "Food for Space Flight," NASA Facts, NP-1996-07-007-JSC, Johnson Space Center, Houston, TX, July 1996.

NASA, "Living in the Space Shuttle," NASA Facts, FS-1995-08-001-JSC, Johnson Space Center, Houston, TX, June 1996.

Please visit *http://spacelink.nasa.gov/space.food* for a wealth of information on the NASA space food program. Also visit NASA Spacelink (*http://spacelink.nasa.gov*) to find the following food lists as well as other information related to the NASA space food program:

- Apollo Food and Beverage List
- Skylab Food and Beverage List

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NASA Educator Resource Center
Mail Stop 253-2
NASA Ames Research Center
Moffett Field, CA 94035-1000
Phone: (650) 604-3574

CT, DE, DC, ME, MD, MA, NH, NJ, NY, PA, RI, VT
NASA Educator Resource Laboratory
Mail Code 130.3
NASA Goddard Space Flight Center
Greenbelt, MD 20771-0001
Phone: (301) 286-8570

CO, KS, NE, NM, ND, OK, SD, TX
JSC Educator Resource Center
Space Center Houston
NASA Johnson Space Center
1601 NASA Road One
Houston, TX 77058-3696
Phone: (281) 483-8696

FL, GA, PR, VI
NASA Educator Resource Laboratory
Mail Code ERL
NASA Kennedy Space Center
Kennedy Space Center, FL 32899-0001
Phone: (407) 867-4090

KY, NC, SC, VA, WV
Virginia Air and Space Museum
NASA Educator Resource Center
NASA Langley Research Center
600 Settler's Landing Road
Hampton, VA 23669-4033
Phone: (757) 727-0900 x 757

IL, IN, MI, MN, OH, WI
NASA Educator Resource Center
Mail Stop 8-1
John H. Glenn Research Center at Lewis Field
21000 Brookpark Road
Cleveland, OH 44135-3191
Phone: (216) 433-2017

AL, AR, IA, LA, MO, TN
U.S. Space and Rocket Center
NASA Educator Resource Center for
NASA Marshall Space Flight Center
P.O. Box 070015
Huntsville, AL 35807-7015
Phone: (205) 544-5812

MS
NASA Educator Resource Center
Building 1200
NASA John C. Stennis Space Center
Stennis Space Center, MS 39529-6000
Phone: (228) 688-3338

NASA Educator Resource Center
JPL Educational Outreach
Mail Stop 601-107
NASA Jet Propulsion Laboratory
4800 Oak Grove Drive
Pasadena, CA 91109-8099
Phone: (818) 354-6916

CA cities near the center
NASA Educator Resource Center
NASA Dryden Flight Research Center
45108 N. 3rd Street East
Lancaster, CA 93535
Phone: (805) 948-7347

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VA and MD's Eastern Shores
NASA Educator Resource Lab
Education Complex—Visitor Center Building J-1
NASA Wallops Flight Facility
Wallops Island, VA 23337-5099
Phone: (757) 824-2297/2298

Regional Educator Resource Centers (RERC's) offer more educators access to NASA educational materials. NASA has formed partnerships with universities, museums, and other educational institutions to serve as RERC's in many states. A complete list of RERC's is available through CORE, or electronically via NASA Spacelink at *http://spacelink.nasa.gov*

NASA's Education Home Page

NASA's Education Home Page serves as a cyber-gateway to information regarding educational programs and services offered by NASA for educators and students across the United States. This high-level directory of information provides specific details and points of contact for all of NASA's educational efforts and Field Center offices.

Educators and students utilizing this site will have access to a comprehensive overview of NASA's educational programs and services, along with a searchable program inventory that has cataloged NASA's educational programs. NASA's on-line resources specifically designed for the educational community are highlighted, as well as home pages offered by NASA's four areas of research and development (including the Aero-Space Technology, Earth Science, Human Exploration and Development of Space, and Space Science Enterprises).

Visit this resource at the following address:
http://education.nasa.gov

NASA Spacelink

NASA Spacelink is one of NASA's electronic resources specifically developed for the educational community. Spacelink is a "virtual library" in which local files and hundreds of NASA World Wide Web links are arranged in a manner familiar to educators. Using the Spacelink search engine, educators can search this virtual library to find information regardless of its location within NASA. Special events, missions, and intriguing NASA web sites are featured in Spacelink's "Hot Topics" and "Cool Picks" areas.

Spacelink is the official home to electronic versions of NASA's Educational Products. NASA educator guides, educational briefs, lithographs, and other materials are cross-referenced throughout Spacelink with related topics and events. Spacelink is also host to the NASA Television Education File schedule. NASA Educational Products can be accessed at the following address: *http://spacelink.nasa.gov/products*

Educators can learn about new NASA Educational Products by subscribing to Spacelink EXPRESS. Spacelink EXPRESS is an electronic mailing list that informs subscribers quickly by e-mail when new NASA educational publications become available on Spacelink.

Spacelink may be accessed at the following address: *http://spacelink.nasa.gov*

Join the NASA Spacelink EXPRESS mailing list to receive announcements of new NASA materials and opportunities for educators. Our goal is to inform you as quickly as possible when new NASA educational publications become available on Spacelink: *http://spacelink.nasa.gov/xh/express.html*

NASA Television (NTV)

NASA Television (NTV) features Space Shuttle mission coverage, live special events, interactive educational live shows, electronic field trips, aviation and space news, and historical NASA footage. Programming has a 3-hour block—Video (News) File, NASA Gallery, and Education File—beginning at noon Eastern and repeated three more times throughout the day.

The Education File features programming for teachers and students on science, mathematics, and technology, including *NASA. . . On the Cutting Edge*, a series of educational live shows. Spacelink is also host to the NTV Education File schedule at: *http://spacelink.nasa.gov/NASA.News/*

These interactive live shows let viewers electronically explore the NASA Centers and laboratories or anywhere scientists, astronauts, and researchers are using cutting-edge aerospace technology. The series is free to registered educational institutions. The live shows and all other NTV programming may be taped for later use.

NTV Weekday Programming Schedules (Eastern Times)

Video File	*NASA Gallery*	*Education File*
12–1 p.m.	1–2 p.m.	2–3 p.m.
3–4 p.m.	4–5 p.m.	5–6 p.m.
6–7 p.m.	7–8 p.m.	8–9 p.m.
9–10 p.m.	10–11 p.m.	11–12 p.m.

Live feeds preempt regularly scheduled programming. Check the Internet for program listings at:
http://www.nasa.gov/ntv/—NTV Home Page
http://www.nasa.gov/—Select "Today at NASA" and "What's New on NASA TV?"
http://spacelink.nasa.gov/NASA.News/—Select "TV Schedules"

Via satellite—GE-2 Satellite, Transponder 9C at 85 degrees West longitude, vertical polarization, with a frequency of 3880.0 megahertz (MHz) and audio of 6.8 MHz—or through collaborating distance learning networks and local cable providers.

For more information on NTV, contact:
NASA TV
NASA Headquarters
Code P-2
Washington, DC 20546-0001
Phone: (202) 358-3572

For more information on the educational live shows, contact:
NASA. . . On the Cutting Edge
NASA Teaching From Space Program
308-A, Watkins CITD Building
Oklahoma State University
Stillwater, OK 74078-8089
E-mail: *edge@aesp.nasa.okstate.edu*

How to Access NASA's Education Materials and Services, EP-1998-03-345-HQ

This brochure serves as a guide to accessing a variety of NASA materials and services for educators. Copies are available through the ERC network, or electronically via NASA Spacelink. NASA Spacelink can be accessed at the following address: *http://spacelink.nasa.gov*

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NATIONAL AERONAUTICS AND SPACE ADMINISTRATION
EDUCATION DIVISION
MAIL CODE FE
WASHINGTON DC 20546–0001

Fold along line and tape closed.

Space Food and Nutrition
An Educator's Guide in Science and Mathematics
EDUCATOR REPLY CARD

To achieve America's goals in Educational Excellence, it is NASA's mission to develop supplementary instructional materials and curricula in science, mathematics, and technology. NASA seeks to involve the educational community in the development and improvement of these materials. Your evaluation and suggestions are vital to continually improving NASA educational materials.

Please take a moment to respond to the statements and questions below. You can submit your response through the Internet or by mail. Send your reply to the following Internet address:

http://ehb2.gsfc.nasa.gov/edcats/educator_guide

You will then be asked to enter your data at the appropriate prompt.

Otherwise, please return the reply card by mail. Thank you.

1. With what grades did you use the educator guide?
   Number of Teachers/Faculty:
   ______ K-4 ______ 5-8 ______ 9-12 ______ Community College
   College/University - ______ Undergraduate ______ Graduate

   Number of Students:
   ______ K-4 ______ 5-8 ______ 9-12 ______ Community College
   College/University - ______ Undergraduate ______ Graduate

   Number of Others:
   ______ Administrators/Staff ______ Parents ______ Professional Groups
   ______ General Public ______ Civic Groups ______ Other

2. What is your home 5- or 9-digit zip code? _ _ _ _ _ — _ _ _ _

3. This is a valuable educator guide?
   ❑ Strongly Agree ❑ Agree ❑ Neutral ❑ Disagree ❑ Strongly Disagree

4. I expect to apply what I learned in this educator guide.
   ❑ Strongly Agree ❑ Agree ❑ Neutral ❑ Disagree ❑ Strongly Disagree

Fold along line and tape closed.

5. What kind of recommendation would you make to someone who asks about this educator guide?
   ❑ Excellent ❑ Good ❑ Average ❑ Poor ❑ Very Poor

6. How did you use this educator guide?
   ❑ Background Information
   ❑ Demonstrate NASA Materials
   ❑ Group Discussions
   ❑ Integration Into Existing Curricula
   ❑ Lecture
   ❑ Team Activities
   ❑ Critical Thinking Tasks
   ❑ Demonstration
   ❑ Hands-On Activities
   ❑ Interdisciplinary Activity
   ❑ Science and Mathematics Standards Integration
   ❑ Other: Please specify: ____________________

7. Where did you learn about this educator guide?
   ❑ NASA Educator Resource Center
   ❑ NASA Central Operation of Resources for Educators (CORE)
   ❑ Institution/School System
   ❑ Fellow Educator
   ❑ Workshop/Conference
   ❑ Other: Please specify: ____________________

8. What features of this educator guide did you find particularly helpful?

   ____
   ____
   ____

9. How can we make this educator guide more effective for you?

   ____
   ____
   ____

10. Additional comments:

   ____
   ____
   ____

Today's Date: ____________________

EG-1999-02-115-HQ

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